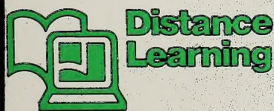




BIOLOGY 20

Matter and Energy in Ecosystems

Module 3



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Biology 20

Module 3

Matter and Energy in Ecosystems



**Distance
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Module 3
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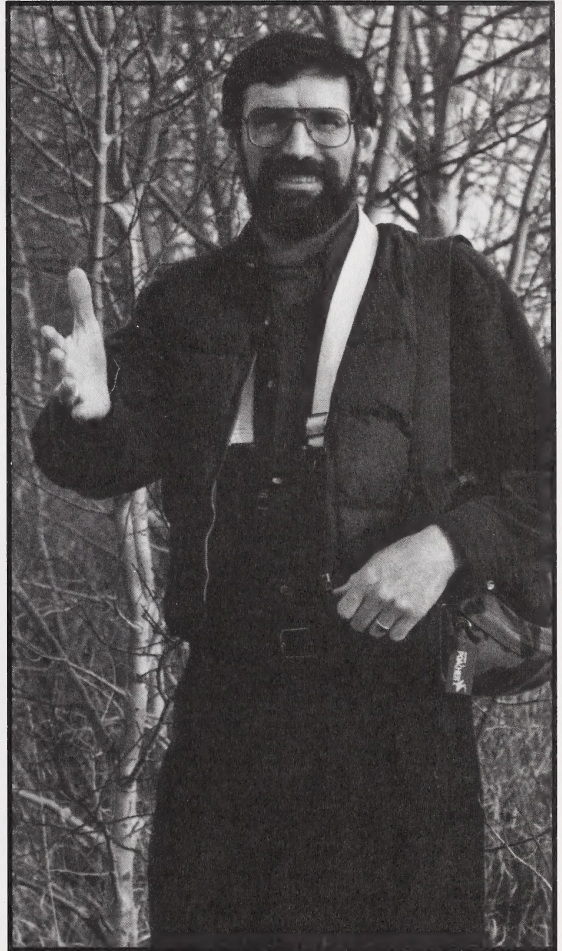
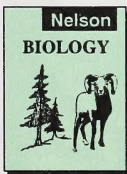
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Welcome to Module 3

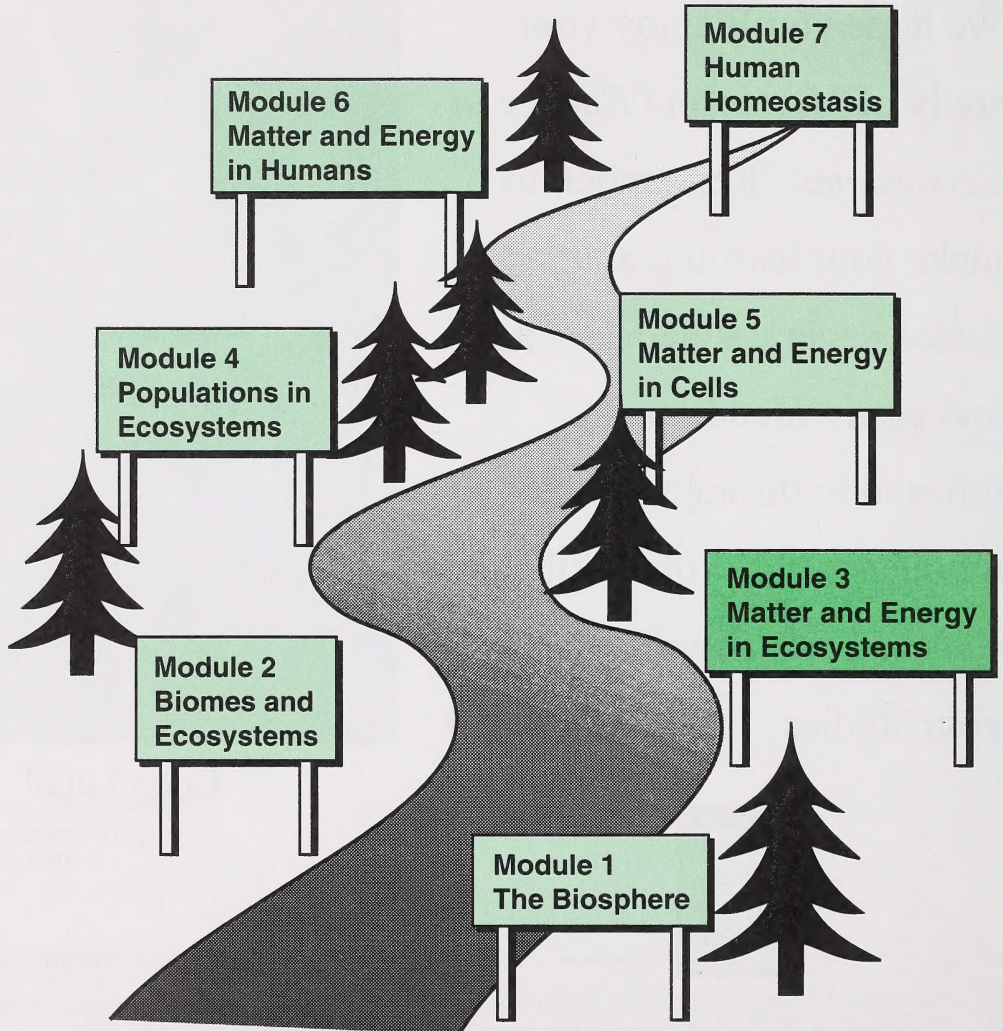
We hope you'll enjoy your study of *Matter and Energy in Ecosystems*. Remember, to make your learning a bit easier, several videocassettes and laser videodiscs are referred to throughout the modules. Also your textbook *Nelson Biology* will enhance your studies.



Good Luck!

COURSE OVERVIEW

This course contains seven modules. The module you are working in is highlighted in a darker colour.



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MODULE OVERVIEW

Have you ever wondered why there are signs on hiking trails in the mountains asking that you remain on the marked trails? Have you wondered why so many people are upset about pulp mills on the Athabasca River? And why is Dr. David Suzuki so concerned about climate and global warming? Does any of this relate to your everyday life? It certainly does!

These issues are all related. They deal with ecosystems and the human impact on them. What happens in any area of the world eventually has an impact on where you live and has the potential to change your quality of life.

Module 1 introduced you to matter and energy in the biosphere. In Module 2 you examined matter and energy in biomes. This module looks at how matter and energy flow in ecosystems. The influence that humans have on these ecosystems and the delicate balance that exists within them will also be studied to give you an appreciation for the multidimensional nature of science, technology, and society.

Module 3 Matter and Energy in Ecosystems



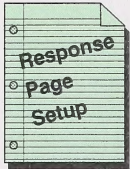
Evaluation

Your mark in this module will be determined by how well you complete the assignments at the end of each section. You must complete all assignments. In this module you are expected to complete three assignments. The mark distribution is as follows:

Section 1 Assignment	50 marks
Section 2 Assignment	<u>50 marks</u>
TOTAL	100 marks

When doing your assignments, work slowly and carefully. If you are having difficulties, go back and review the appropriate section.

Read all parts of your assignment carefully. Plan and do your rough work on your own paper. Revise and edit your responses; then set up your final copy for submission on your own paper. Lined looseleaf is recommended. Make sure your answers are neat and organized, with wide left margins and space for teacher comments after each assignment.



When you see this icon, ideas and details are provided to help you set up and organize your answer in a certain way.

Before submitting your responses, be sure to proofread them carefully to ensure they say what you want, that they are neat and clear, and that they are complete and missing no material.

You will be submitting **only** your **assignment response pages** for evaluation.

It is important to number and clearly identify each page with this information placed at the top.

Biology 20 – Module 3 **Section # Assignment** **Page #** **Name and ID #**

SECTION

1

Matter and Energy Flow



WESTFILE INC.

As a living organism you need a daily input of energy in order to walk, talk, sleep, play, and complete your Biology 20 modules. The cyclists in the previous photo are expending a great deal of energy on their ride. Where does the energy come from and where does it go? You are probably aware that they take in food and water for this effort. Have you ever thought about where the energy comes from that ends up in the food you eat? Where do you fit in the energy pathways or ecosystems that make up a biosphere? Are you a part of an ecosystem?

In this section you will learn more about ecosystems. You will examine how energy flows through ecosystems in simple food chains and how they are interconnected with more complex food webs. And, finally, you will develop a model for a terrestrial and aquatic ecosystem and possibly gain an insight into where you fit.

ACTIVITY

1 Ecosystems

As you discovered in Module 1, you live and function within the biosphere. In Module 2 you saw how biotic and abiotic factors of the environment relate to the biosphere and form various biomes. Have you ever thought of yourself as a miniature biosphere? The organization of the biosphere, with its related energy input and outflow, can be compared to a functioning organism like yourself. To see how, read the section titled The Biosphere on pages 21 and 22 of your text.



Within the biosphere you should be able to recognize various ecosystems just as you can recognize body organs. To begin this recognition, compare your body's organization to an Alberta ecosystem – the Aspen Parkland. Using the following two drawings, complete the chart that follows. Keep in mind that like body organ systems, ecosystems are active.

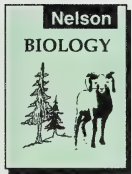


1. Use the following comparison chart to name as many examples as you can.

HUMAN BODY		ASPEN PARKLAND	
Level	Example	Level	Example
cell		organism	
tissue		population	
organ		community	
organ system		ecosystem	
organism	you	biosphere	

Check your answers by turning to the Appendix, Section 1: Activity 1.

How many organ systems were you able to name? If you identified seven, you did really well. Think about these organ systems with respect to ecosystems operating within the biosphere. An organ system is a collection of tissues and organs that keep you alive and functioning. An ecosystem is a collection of populations and communities that keep the biosphere alive and functioning. Now you can see how an ecosystem fits into the total picture of the biosphere.



What is an ecosystem? Refer to pages 22 and 44 of your text and read the descriptions given.

2. Now write your own definition of an ecosystem.

You should already understand the importance of the interaction of biotic and abiotic factors in an ecosystem. If you're not sure, go back and read page 21 of the text to review biotic and abiotic components.

3. Now go back to the picture of the Aspen Parkland and list as many biotic and abiotic factors as you can.

Check your answers by turning to the Appendix, Section 1: Activity 1.

These biotic and abiotic factors interact within the ecosystem and are key to its dynamic functioning. If any factors change, the ecosystem will be affected. Read pages 44 to 46 in your text and answer the following questions.

4. Explain how the boundaries of an ecosystem are determined.

5. Describe why some boundaries may be less distinct.
6. Refer to Figure 2.2 on page 45 in your text; then describe the most important driving force of an ecosystem. How is it integrated into the biosphere?



Look at two scenes common to aquatic ecosystems in Alberta.



COURTESY OF D. MERRILLS



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7. Compare the effect on each ecosystem of keeping a fish or releasing it back into the water. Think about matter and energy.
8. Why do you think ecosystems are not always **self-sustaining**?

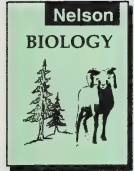
self-sustaining
– capable of naturally maintaining communities and populations of organisms over a long period of time

Check your answers by turning to the Appendix, Section 1: Activity 1.

You should now realize that an ecosystem is dynamic and that the interaction of biotic and abiotic factors is key to its natural function.

Water in Ecosystems

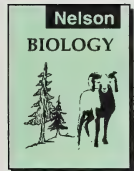
It is easy to recognize whether an ecosystem is aquatic or terrestrial. Regardless, all ecosystems depend on water to support life. You were introduced to water and to aquatic ecosystems in Module 2. To organize your knowledge of the importance and unique properties of water, complete the following statements by filling in the blanks on your own paper. Read pages 66 to 70 in your text again if necessary.



combustible –
can burn or
support burning

9. a. Water is the world's greatest natural _____. Approximately _____% of the human body is water. Water covers _____ of the planet. Oceans control _____ patterns on Earth. The greatest portion of fresh water is stored as _____ and _____.
- b. Water can be used to extinguish fires but contains _____ and _____, two highly **combustible** gases. A water molecule attracts other molecules, including _____. Water _____ when cooled to form ice. Water is a _____ and as such is rarely found in its pure form in nature. Water has the ability to store heat and therefore moderate _____.

Check your answers by turning to the Appendix, Section 1: Activity 1.



10. You should now be able to answer the Review Questions on page 71 of your text. Answer all seven questions. Do your comparison for question 6 in chart form. Use the following headings to make a chart for your answer.

OLIGOTROPHIC	EUTROPHIC
--------------	-----------

Check your answers by turning to the Appendix, Section 1: Activity 1.

You should now understand why water is so important to ecosystems and how different aquatic ecosystems are formed and function.

Don't lose sight of the fact that the biosphere is made up of aquatic and terrestrial ecosystems which function individually yet are integrated with each other. Terrestrial ecosystems may be considered more complex than aquatic ecosystems because of the greater variation of abiotic factors.



To gain a better understanding of ecosystems, watch the video, *Aspects of Ecology: Ecosystems*. As you watch the video, answer the following questions. Use the pause button to give yourself ample time to respond.

stability –
resistance to
change

11. Make a list of six features of an ecosystem defined at the beginning of this video?
12. Explain the differences between tropical and arctic ecosystems in terms of **stability**.
13. Humans often intervene in order to manage ecosystems. Give four examples of the interventions described in the video and the possible risks and benefits of them. You may have to develop the risks on your own in each case.
14. What is of key importance to all ecosystems?
15. Explain why the reduction and hopefully the elimination of phosphates from water systems in Calgary and Edmonton would improve the water quality of the Bow, Elbow, and North Saskatchewan Rivers.
16. How do the pH values for normal and acid rain compare?
17. What three sources are named as contributors to acid rain in Alberta?
18. Many companies claim to put the ecosystem back into the state in which it was found in a process called **reclamation**. Comment on this claim based on what you know about aquatic ecosystems and how they function.

reclamation –
restoring the
biotic and abiotic
factors of an
ecosystem

Check your answers by turning to the Appendix, Section 1: Activity 1.

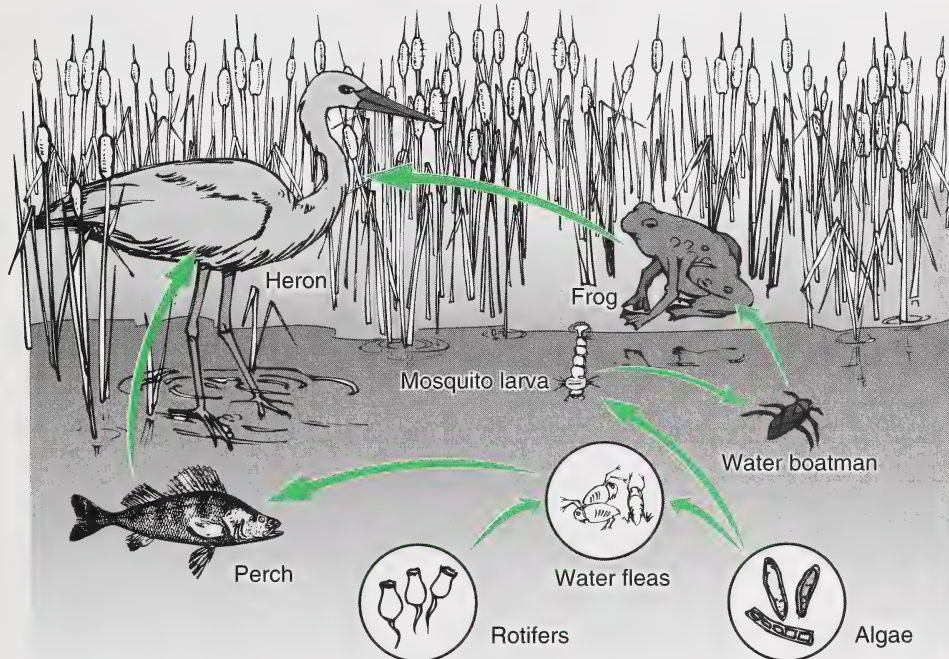
By now you should appreciate that ecosystems have characteristic structures determined by their flow of matter and energy. Regardless of what kind of ecosystem is examined, these basic structures will always be present. So what are these basic structures? You will learn about them in Activity 2.

ACTIVITY

2 Trophic Structures in Ecosystems

In Module 1 you learned about the Laws of Thermodynamics and how they relate to the flow of energy within the biosphere. You also learned that matter can be recycled but energy cannot. In this activity you will see how energy (food) relates to the ecosystems that you studied in the first activity.

The following drawing depicts populations typical of a freshwater pond ecosystem. The arrows indicate the flow of energy.



View the program *Circles and Cycles* on the *Aspects of Ecology* video. As you watch the video, answer questions 1 to 5. Stop the tape whenever necessary.

You may also refer to pages 46 to 49 in your text for help.

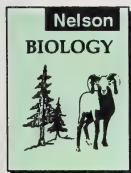
1. a. Compose a definition for each of the following key energy levels in an ecosystem:

- | | | | |
|----------------|--------------|---------------|--------------|
| • autotrophs | • consumers | • producers | • carnivores |
| • heterotrophs | • herbivores | • decomposers | • omnivores |

- b. Create a concept map using the terms from 1. a. The concept map should be arranged in the order that the energy levels interact. Use arrows to indicate the direction that energy will flow. Remember that the arrangement should be of use to you.

You should notice that energy flows from all levels to the decomposers. Your concept map represents two generalized food chains: a grazer food chain and a decomposer food chain.

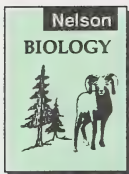
2. What is the role of decomposers in the flow of matter and energy in an ecosystem?



Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

3. a. What is a food chain?
- b. Compare a grazer food chain with a decomposer food chain.
4. Refer to the discussion on page 47 and Table 2.2 on page 49 in your text, and make up a definition for *trophic level*. Include examples in your definition.
5. How does an omnivore differ from a carnivore and a herbivore? Give an example of each from your reading in the text.



Check your answers by turning to the Appendix, Section 1: Activity 2.



ALBERTA RECREATION AND PARKS

Some of the species in the preceding graphic include the following:

- | | | |
|----------|-----------------|--|
| • beaver | • common loon | • poplar and birch trees |
| • wolf | • insects | • great grey owl |
| • osprey | • perch | • aquatic vegetation |
| • moose | • bunchberry | • nuts and berries from black and white spruce |
| • seeds | • goldeneye | • red-backed vole |
| • lynx | • red squirrel | • yellow-bellied sapsucker |
| • birch | • tamarack | • wild sarsaparilla |
| • otter | • northern pike | |

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

6. Develop five food chains from the preceding list and graphic. Include food chains having three, four, and five trophic levels.

Check your answers by turning to the Appendix, Section 1: Activity 2.

Food chains are only part of the story concerning energy flow. Read about Food Webs on pages 49 and 50 of your text to learn more about important interrelationships dealing with energy.

7. Distinguish between a food chain and a food web.
8. Using the preceding graphic and list of organisms, construct a food web for the Northern Forest ecosystem. You need not use all the species shown in the graphic, but you should develop a well-connected food web which represents the dynamics of this ecosystem.

Check your answers by turning to the Appendix, Section 1: Activity 2.

Matter is continually entering ecosystems and food webs. You learned in Module 1 how this works. What if some of the matter entering a food web was harmful? How do you think it might affect the ecosystem?

To find out how, read pages 60 and 61 in your text.

9. A **toxin** called dieldrin was sprayed on an island north of Borneo to combat mosquitoes causing malaria. Describe how a change in one part of a food web caused by the dieldrin could impact on many other parts of the web.

In her book *Silent Spring*, Rachel Carson warned about the harmful effects of indiscriminate use of pesticides. Research has shown that toxins do accumulate and magnify in food chains in a process of **biological amplification**. Recall the discussion of DDT and peregrine falcons in Alberta shown in the video *Circles and Cycles*.

10. Define biological amplification and discuss the ways that it applies to food chains and food webs.
11. Use of DDT was banned in Canada and the United States in the late 1970s, but its manufacture was not. It is still sold to Third World countries. Discuss this situation in terms of migrating birds and fish and their effect on food webs.



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effluent – waste products from industry or agriculture

Human activities often affect aquatic ecosystems. **Effluents** from urban industrialized cities frequently contain harmful chemical pollutants. Heavy metals, such as mercury, lead, and cadmium, as well as other chemicals (dioxin and PCBs), are found in the effluents.

Science Skills

- ☒ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

12. With your knowledge of food chains, food webs, and ecosystems, prepare a short report that could be presented to the Alberta Environment Minister to stop companies from dumping these chemical pollutants into water systems.

Check your answers by turning to the Appendix, Section 1: Activity 2.

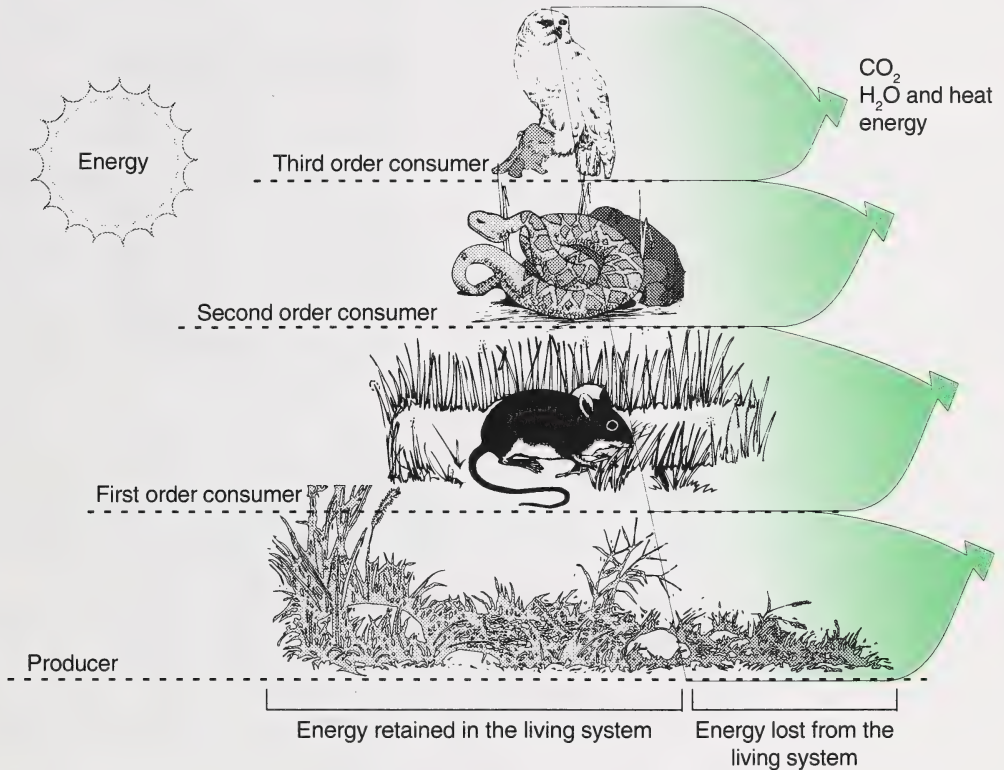
ACTIVITY

3

A Model Ecosystem

You have seen how energy flows through the various trophic levels in an ecosystem and how food webs can be affected by toxins in the environment. The trophic level groups that ecologists use allow them to study complex interactions in a more understandable way. Ecologists also study the rates at which each trophic level obtains food, energy, and nutrients from other species and the environment. By focussing on the transfer of energy and the movements of nutrient molecules, models can be built which summarize the interactions between the trophic levels in an ecosystem.

This figure shows energy flow in an ecological pyramid. At each step, an appreciable portion of energy originally trapped by the producer is lost as heat. Accordingly, organisms in each trophic level pass on less energy than they received.



To help build this model, read pages 56 and 57 of your text.

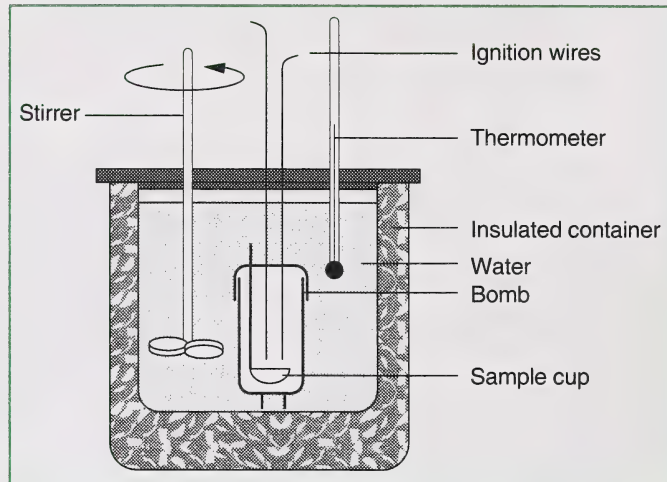
1. Give a definition of an *ecological pyramid*. What does an ecological pyramid represent?
2. There are three types of pyramids in common use by ecologists. State what each of these represents and comment on the accuracy of each as a measurement of the energy use and loss in an ecosystem.

Calorimetry

Energy and matter in an ecosystem can be partially measured using a technique called **calorimetry**. A known amount of organic material is burned in a calorimeter similar to this diagram. The released energy can be measured.

calorimetry – the measurement of the amount of heat energy in a substance

The addition of oxygen to the bomb calorimeter ensures that the substance undergoes complete combustion. As combustion progresses, the heat from combustion will heat water surrounding the calorimeter. This heating of water can then be mathematically converted to an energy value in joules.



3. What trophic level is able to capture the most energy and why?

Check your answers by turning to the Appendix, Section 1: Activity 3.

Now that you have an understanding about the matter and energy relationships in ecosystems, you should be ready to make your own model ecosystem. Use Figure 2.16 on page 57 of your text and refer back to Activity 2: question 1 to help you. You should also recall that CO_2 was produced during respiration as shown in the graphic at the beginning of this activity. This was introduced in Module 1. You will learn more about respiration in Module 5.

Note: Detritus is the material formed by the dead bodies of plants and animals. It becomes food for decomposers.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

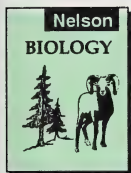
4. Construct a model ecosystem by using arrows to connect the following items. Remember, the arrows show the flow of energy and matter.
- CO_2
 - Sun
 - Producers (Plants)
 - Decomposers
 - Consumers
 - Inorganic Nutrients (Biogeochemical Cycles)
5. Discuss how the model ecosystem that you developed could apply to aquatic or terrestrial ecosystems.

Check your answers by turning to the Appendix, Section 1: Activity 3.

Follow-up Activities

If you had difficulties with the activities in this section, it is recommended that you do the Extra Help. If you have a clear understanding of the main ideas and had few difficulties with the activities, it is recommended that you do the Enrichment.

Extra Help



Carefully read the Chapter Highlights on page 64 of your text, and then complete the following questions.

1. Write a description for an ecosystem.
2. Using examples, distinguish between biotic and abiotic factors.
3. Why are abiotic and biotic factors of the environment so important to ecosystems?
4. a. Distinguish between each of the following:
 - producers • consumers • decomposers
- b. Give three examples for each of the terms in 4. a. In the case of consumers your examples should include one from each of three trophic levels.
5. Using examples, explain the difference between food chains and food webs.
6. Compare and contrast aquatic and terrestrial ecosystems.

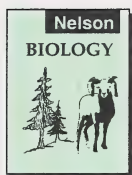
Check your answers by turning to the Appendix, Section 1: Extra Help.

Enrichment

Do any or all of the following.

1. Use the *Guide to the Native Trees and Shrubs of Alberta* and / or the *Guide to Aquatic Invertebrates of Alberta* (Devonian Gardens) and study an aquatic or terrestrial ecosystem. Identify the members of the various trophic levels of your chosen area of study and develop a food web for your chosen study area. You may choose your study area from one of the following biomes of Alberta:
 - Grassland biome • Northern Forest biome • Aspen Parkland biome
 - Rocky Mountain biome • Central Foothill biome

2. Many different types of interactions take place within an ecosystem. You have been studying predation as it relates to food chains and food webs. Another interaction is parasitism. Go to a local library and research the life cycle of malaria (*Plasmodium*). The important point to recognize is how integrated the parasite is with its host species. Although this species affects human populations, there are many malarial species that affect native bird populations in Canada. Based on the human malarial life cycle, hypothesize what you think the bird malarial life cycle might be like. Draw the two life cycles.
3. Using the five biomes of Alberta from question 1, compare the trophic structure of any two of these biomes. In this comparison, make a list of the organisms that occupy the various trophic levels and use examples of food chains to complete your comparison.
4. If you did not complete the Investigation on page 93 in your text in Module 2 and are doing this module in the winter, read the section in your text entitled Winter in Northern Ecosystems on pages 77 to 91 and perform the Investigation outlined on page 93. Answer the Laboratory Application Questions.
5. Read the Critical-Thinking Questions on page 65 in your text. Do you feel in familiar territory? As a student of biology you should be able to consider these questions.



Check your answers by turning to the Appendix, Section 1: Enrichment.

Conclusion

In this section you learned about the structure and dynamic interactions that make up an ecosystem. You also learned about the steps involved in determining the flow of energy through ecosystems and the various trophic – or feeding – levels. You developed a model for an ecosystem that was general enough to be applied to terrestrial or aquatic environments. You also studied the effects that humans may have on various ecosystems through the use of pesticides such as dieldrin and its disastrous effect on the process of biological amplification.

50

Section 1 Assignment: Matter and Energy Flow

Review the Evaluation information found in the introductory pages of this module.

It is important to number and clearly identify each page with the following information at the top:

Biology 20 – Module 3

Section 1 Assignment

Page #

Name and ID#

Be sure to write legibly. Leave a wide left margin and number all of your pages.

Natural ecosystems tend to be stable and exhibit certain characteristics such as a balance with the environment. Human-made ecosystems tend not to achieve a balance with the environment and are generally self-serving.

1. a. Compare the flow of energy in a natural ecosystem, such as a herd of whitetailed deer in a woodlot, to an unnatural ecosystem, such as a herd of cattle in a pasture. **(5 marks)**

b. Compare the cycle of matter in the two ecosystems described in question 1. a. **(5 marks)**
2. Describe how autotrophs and heterotrophs occupy two separate and distinct trophic levels in an ecosystem. **(10 marks)**
3. Using the general names for trophic levels (producer, consumer, and decomposer) as well as specific examples, describe the energy pathway in each of the following:
 - a. grazer food chain **(5 marks)**
 - b. decomposer food chain **(5 marks)**
4. Explain how food webs are formed in ecosystems. Include a diagram in your answer. You may use **P** for producer and **C** for consumer. **(10 marks)**
5. People who fish are often warned not to eat fish caught in certain rivers because they contain mercury. Describe how mercury would get into the fish and name the ecological process involved which could produce toxic levels in fish and eventually in humans. **(10 marks)**

SECTION

2

Human Impact



COURTESY OF DUCKS UNLIMITED

It has been said that wetland ecosystems are the most productive in the world. What would happen to the ecosystem in the preceding picture if the water was drained away? Right, the effect would be drastic! Can you think of situations near where you live where this has happened?

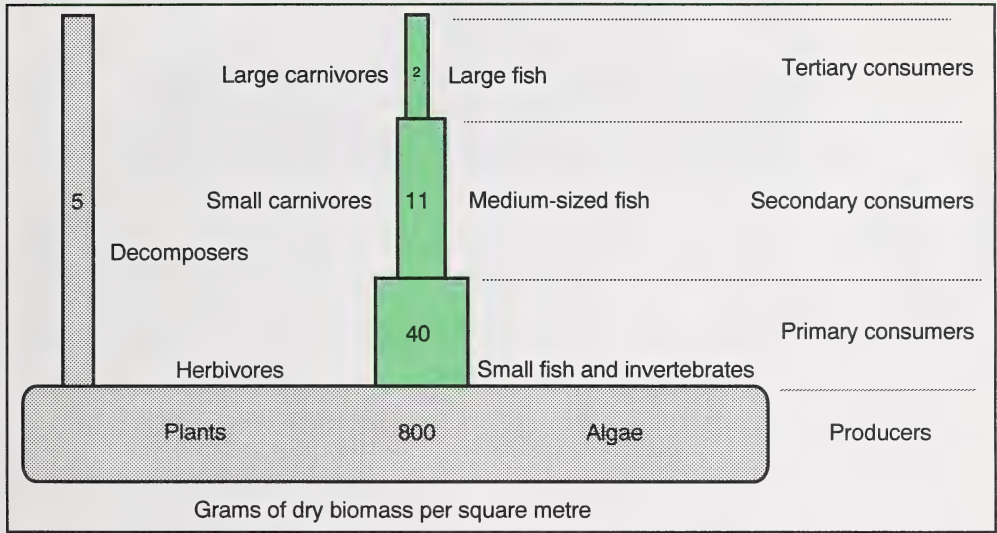
Unfortunately, draining wetlands and clearing forests are very common human activities that affect ecosystems. When considering these activities, it is not sufficient to say, "Oh, the ecosystem will be affected." You need to be able to say how and how much. This requires a more detailed knowledge of ecosystems. You've made a good start in Section 1.

In this section you will learn about the quantitative energy relationships in ecosystems. You will examine monocultures and learn about the impact humans have on ecosystems by examining wetland ecosystems. The effect of pulp and paper mills on the Athabasca River system will also be investigated.

ACTIVITY

1

A Quantitative Look at Trophic Structures



In Module 1 and the first section of this module, you were introduced to the concept of energy and how it flows through ecosystems. Recall the battery farm chickens that you viewed in the video in Module 1. It took 100 g of feed to produce 1 g of egg which showed an efficiency of 1%. Thus, energy was seen to flow through this system and not recycle within it.

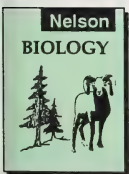
This energy flow was further developed in Activity 3 in Section 1 of this module where you were introduced to ecological pyramids and how energy flow through ecosystems is studied.

The pyramid of biomass shows that the transfer of energy from one level to the next is never 100% efficient; therefore, the biomass of each successive group is less. Note the constant biomass of decomposers at all levels of the pyramid.

In this activity you will be using actual values to examine ecosystems.

As a brief review, read Ecological Pyramids on pages 56 and 57 in your text. Then answer the next three questions.

1. Name the three types of ecological pyramids.
2. Which pyramid is the most valid for measuring the energy flow and comparing one ecosystem with another? Explain your answer.



The following data relate to a grassland ecosystem.

Grassland Ecosystem Data:

Producers (P)	1 500 000 individuals
Primary Consumers (C_1)	200 000 individuals
Secondary Consumers (C_2)	90 000 individuals
Tertiary Consumers (C_3)	1 individual
Decomposers (D)	100 000 individuals

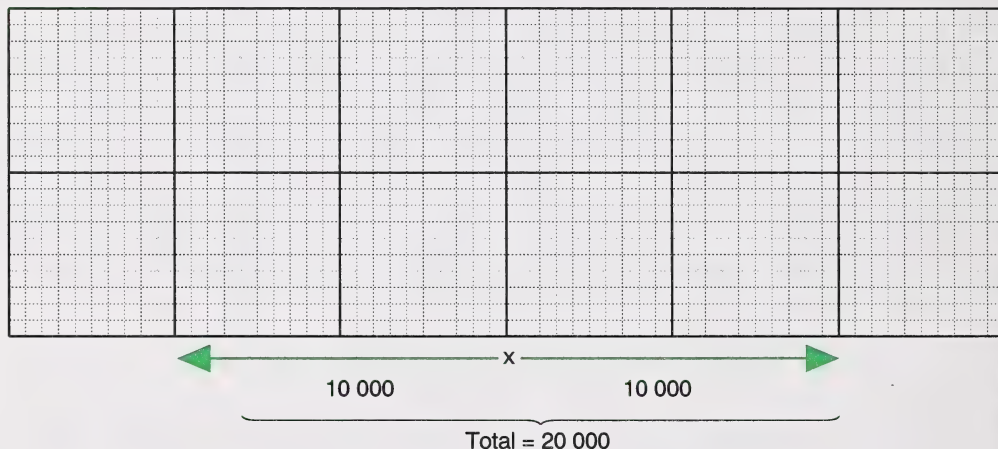
Science Skills

- ☒ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

3. Use your own graph paper to plot a pyramid of numbers. The steps that you use to represent the various levels are all the same **height**, but the **width** will differ. Decomposers are represented by extra bar(s) placed on top of the primary producers and extending to the highest carnivore, as shown in the graphic introducing you to this activity. Use the pyramid of biomass at the beginning of this section and on page 56 in your text to help you. Let each main column on the graph represent 100 000 individuals.

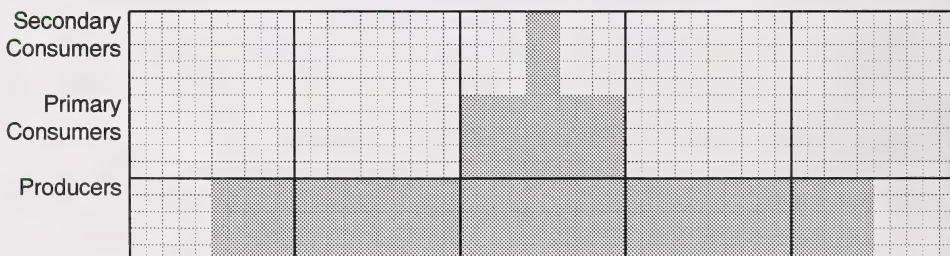
Here is a new type of graph for you. Here are a few hints about using this type of graph.

- On the horizontal axis count from the centre in both directions to make a wide bar.

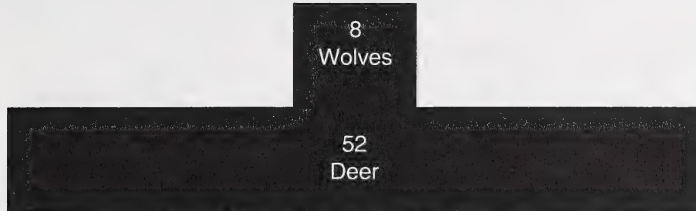


arbitrary – simply established to create a point of reference

- The height of each bar is **arbitrary**. Each bar just represents a trophic level. Use a convenient height.



So why do the numbers get smaller? Ask yourself this: If a wolf pack of eight wolves eats one deer per week, how many deer are needed to feed the wolves for a year? About fifty-two deer are needed. So this numbers pyramid would look like this:



Now, how many plants do fifty-two deer eat in one year? This is a difficult question and even a more difficult bar graph. Maybe some other index is better – like energy. Check Figure 2.15 on page 57 in your text. This is a pyramid of energy as kilojoules per square metre per year. This energy could be in sunlight, plants, deer, or wolves. It still adds up.

Science Skills

- ☒ A. Initiating
- ☐ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

4. Now for comparison, plot a pyramid of **energy** for an Arctic ecosystem on your own graph paper. Use the following data.

Data for an Arctic Ecosystem:

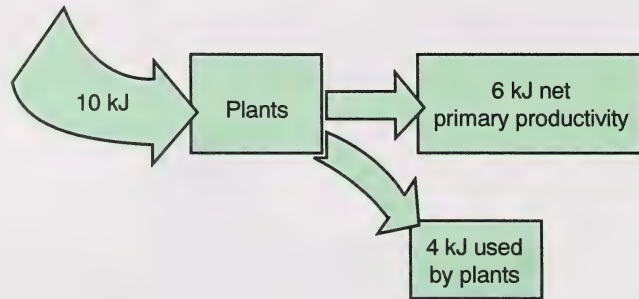
Producers (P)	3600 kJ/m ² /a
Primary Consumers (C ₁)	24 kJ/m ² /a
Secondary Consumers (C ₂)	4 kJ/m ² /a
Decomposer bacteria (D ₁)	414 kJ/m ² /a
Decomposer fungi (D ₂)	63 kJ/m ² /a

5. Why is the pyramid of energy flow for a given ecosystem always pyramidal in shape?

Check your answers by turning to the Appendix, Section 2: Activity 1.

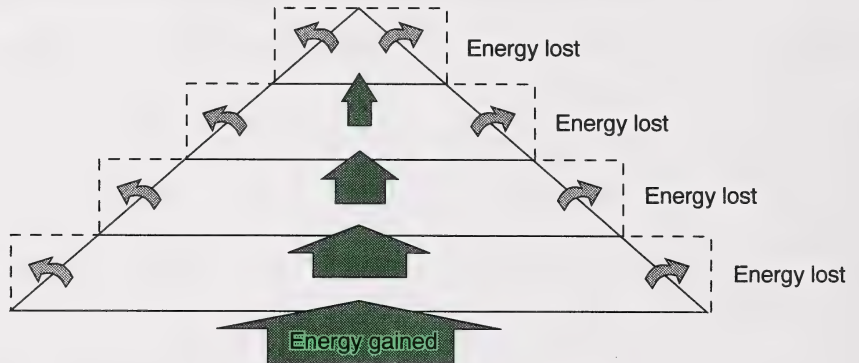
You have probably wondered how the data for energy was obtained. Ecologists calculate how much energy is available to consumers in a specific ecosystem by first determining the total light energy for a given amount of time converted by producers to chemical energy in photosynthesis. This is called the **gross primary productivity**. Next, they subtract the amount of energy used by producers for respiration to arrive at the **net primary productivity**.

Look at it this way. Plants may take in 10 kJ, use 4 kJ, and store 6 kJ. (The 6 kJ of energy can be passed to the next level.)

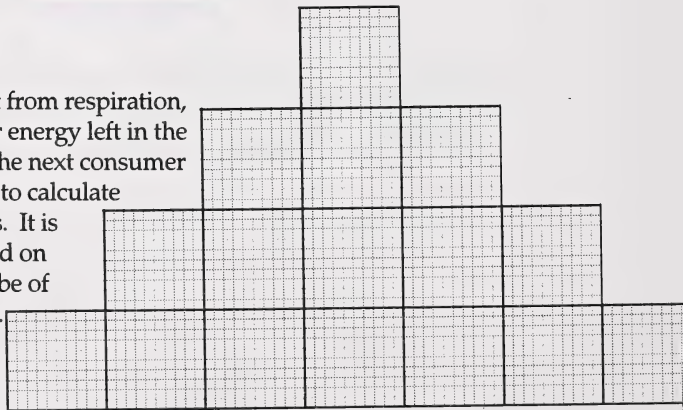


Actual amounts of energy are not as simple as 4, 6, and 10 kJ. Rather the amounts may be much larger, especially when calculated per square metre per year.

Here is another way to look at an energy pyramid. The most important thing to realize is that not all the energy taken in at one level is passed on to the next.

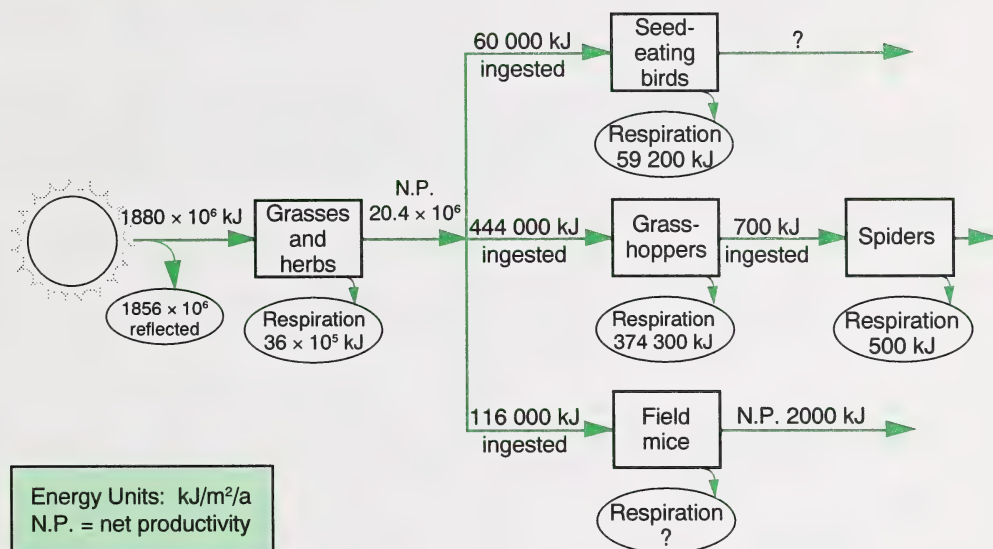


The lost energy could be heat from respiration, chemical energy in wastes, or energy left in the biomass that is not eaten by the next consumer level. Lost energy is difficult to calculate because of the different kinds. It is easier to work with the passed on energy. This pyramid could be of numbers, biomass, or energy.



Next, you'll have an opportunity to examine energy flow through part of a grassland ecosystem using fairly realistic energy values. Carefully examine the next figure and then answer questions 6 to 12.

Grassland Ecosystem Energy Flow



6. Which of the rectangular boxes in the preceding illustration represents the following?
 - producers • primary consumers • secondary consumers
7. Calculate the energy trapped by the grasses and herbs in photosynthesis.
8. Why are the grasses and herbs so inefficient at trapping the light energy? Is this normal for producers?
9. What is the primary production of each of the following groups:
 - seed-eating birds • grasshoppers • spiders
10. How much energy is lost through respiration and feces by field mice?

Remember, not all net productivity energy will be passed to the next level. Notice that the ingested total by seed-eating birds, grasshoppers, and field mice is less than the net productivity of plants. The difference makes up that amount of uningested plant material that decays. This is passed to **decomposers**.

Check your answers by turning to the Appendix, Section 2: Activity 1.

11. Use your own graph paper to complete a pyramid of energy for the grassland ecosystem. You will find two irregularities: one dealing with the energy values when plotting producers and primary consumers; the other dealing with the organisms to be represented in the primary consumer level.

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

12. Discuss the two irregularities that you had with plotting this energy flow graph.
13. Can you speculate on what the energy flow picture in this grassland ecosystem might look like over the next several years?

Check your answers by turning to the Appendix, Section 2: Activity 1.

You have now seen how ecologists can calculate productivities within ecosystems and how a relatively accurate picture of energy flow can be created. Matter does cycle within ecosystems and is reused but energy does not cycle. Energy flows through ecosystems with an amount that is always lost. This energy must be regained by the ecosystem from sunlight which is captured by producers in photosynthesis.

Have you ever wondered where farming fits into this energy picture? When a specific area is cultivated and certain plants are grown exclusively in this area, what happens to the energy balance? You will learn about this in the next activity.

ACTIVITY

2 The Effects of Single Crop Monocultures

Here's something to try sometime. If you can find a place where a natural, uncultivated area exists beside a planted crop, count the number of different kinds of plants in each area. You may even be able to make an interesting poster by collecting and displaying the available leaves of each area. A planted crop in a cultivated field represents a **monoculture**, or a situation where only one species of organism is allowed to exist. This is rarely found in nature. Humans use monocultures for various purposes, such as high productivity on farms. Monocultures can include plants like wheat or barley, or animals like chickens or cattle. Biodiversity is practically eliminated in monocultures. So what happens to food chains, food webs, and ecological pyramids?

monoculture – a single species of plant grown in an area



Nelson

BIOLOGY



To see how monocultures relate to the ecological pyramids that you have been examining, read *Interfering with Ecological Pyramids* on pages 58, 59, and the concluding paragraph on page 60.

1. Explain the meaning of the term *monoculture*.
2. Describe how temperate ecosystems can vary from season to season.
3. Categorize the large-scale changes in an ecosystem that can alter the populations within it. Give examples in each of the categories.
4. What do the fossil records reveal about **biological diversity** (biodiversity) and the number of species now living on the Earth?
5. Explain the meaning of the term *biodiversity*.
6. Comment on what you think the effect of decreased biodiversity will have on food webs.
7. Discuss the danger of eliminating wild species of plants that have never been classified in order to grow a plant monoculture.
8. Describe the overall effects of replacing tropical rain forest ecosystems with monocultures. Your answer should address soil suitability, nutrient cycling of matter, biodiversity, and overall success of the replacement.

Check your answers by turning to the Appendix, Section 2: Activity 2.

Monoculturing of plant species such as wheat for food production is necessary but it poses many questions. Keeping a balance between monocultures and the naturally occurring ecosystems is the challenge to humans. Monocultures themselves must be well managed to make the most of the available land on which they are grown and not disrupt the natural biogeochemical cycles.

ACTIVITY

3

Reclamation of Wetland Habitats

Ozone depletion, deforestation, pollution, monocultures, – what's happening? This sounds quite gloomy. Maybe it's time to study something positive. Examine the figures on the following table. Notice how the values for **biomass** and **energy** both decrease down the table.



COURTESY OF DUCKS UNLIMITED

Net Primary Productivity of Some Major Canadian Ecosystems

ECOSYSTEM	BIOMASS (kJ/m ² /a)	ENERGY (kJ/m ² /a)
Wetland (coastal marsh)	2.50	50 400
Temperate Rain Forest	1.50	40 000
Temperate Deciduous Forest	1.20	33 600
Mountain Coniferous Forest	1.30	25 000
Cultivated Field (monoculture)	0.65	12 600
Grasslands	0.60	10 500
Open Ocean	0.13	4 200
Tundra	0.15	840
Desert	0.13	840

As you can see from the preceding table, wetlands are the most productive ecosystem. You are probably wondering what wetlands are. As the name suggests they are land areas covered with water. Some contain water all year while others hold water at only certain times of the year. Many wetlands have shallow water of one metre or less in depth.

If you have ever flown over the prairie provinces, you would have noticed that the landscape is covered with small bodies of water. They were formed about 10 000 years ago when the glacial ice sheets retreated, leaving hills and hollows behind. The hollows or potholes filled with water and formed ponds and lakes.



COURTESY OF DUCKS UNLIMITED

Some wetlands form wherever there is low-lying land where water can accumulate after a heavy rainfall or snowmelt. Other wetlands form on flood plains along rivers. Beaver activities and human activities, such as building water reservoirs and farm dugouts, account for other wetland formations.

So how important are wetlands? Can anything be done to save them?

View the video *If You Build It* in order to gain an appreciation of what is at stake in wetland habitats and then answer questions 1 to 4.

You should look at the questions first so that you will be aware of what is being asked as you watch the video. Stop the tape whenever necessary.

1. Wetlands took thousands of years to develop; in one century humans have destroyed most of them. List five reasons given for this destruction.
2. To save wetlands, Marshall, the narrator, suggests three things (management strategies) that can be done. State one of these and give a brief explanation of it.
3. Summarize the findings of each of the wetland conservationists – Nathan, Katie, and Chris – in their respective areas of Alberta. What type of management strategy was used in each case?

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

4. What is the message that concludes the video *If You Build It*?

Check your answers by turning to the Appendix, Section 2: Activity 3.

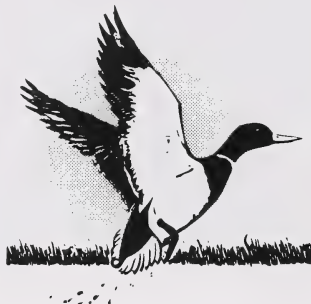
Read the article *Reversing The Duck Disaster* to give you a more detailed account of why wetlands are extremely important. Then answer questions 5 to 7.

Reversing the Duck Disaster

Help is on the way for battered waterfowl populations

Once it was known as the “duck factory” of North America. Nestled among the wheat fields and pastures of the southern prairies, a patchwork of small wetlands hosted 20 million breeding ducks every summer in the early 1970s. Today, the same region sustains less than half that population. Last year saw the second lowest fall flight of Canadian ducks on record; the lowest was just three years before. Worried by the decade-long decline, waterfowl managers across the continent have been scrambling to develop effective countermeasures. The result is an ambitious \$1.5 billion agreement known as the North American Waterfowl Management Plan.

Managers already knew the main culprits causing the decline. “For a few species like black duck we are seeing impacts of acid rain,” said Jim Patterson, Director of Wildlife Conservation for Wildlife Habitat Canada, “but the main damage is from degradation and loss of habitat, especially on the prairies.” In part, that habitat loss is due to drainage of potholes and other wetlands, which has destroyed 40% of original prairie wetlands. Loss of native grasslands around the remaining wet areas is another key factor, since these grassy uplands provide nesting habitat for many ducks. Because of reduced grass cover, a mallard sitting on the nest



MALLARD: PRAIRIE DUCKS IN TROUBLE

now has only one chance in ten of actually hatching her brood in some parts of the prairies.

These habitat losses are the result of expanding farm operations, especially on marginal soils previously left untouched. Fuelled by high grain prices and aggressive government policies in the 1960s, this expansion led to serious environmental and economic problems for the region. Soil degradation through erosion and salinization costs farmers \$1 billion per year, according to a Senate committee report. Expenditures made by Canadians to watch or hunt waterfowl have declined \$250 million per year since 1980. Said Patterson: “Even for purely economic reasons, that land has to be managed in a different way.”

The Waterfowl Management Plan represents a new approach in wildlife conservation. Rather than

buying large plots of land, the Plan provides incentives for farmers to manage their lands in a sustainable way, both for agriculture and for waterfowl. A farmer could be given cash payments to seed grasses on marginal lands, or to pay for fences to allow pasture rotation that retains nesting cover. Improved payments for crop damage by waterfowl are also provided by the Plan’s strategy. Over the next 15 years, the majority of Plan expenditures – a projected total of \$1 billion – will be in Canada. Three-quarters of that will come from American government and non-government sources.

While most of the spending under the Waterfowl Management Plan will be channelled through provincial government agencies, private conservation groups such as Ducks Unlimited Canada will also play a role. With a 50-year history of working with private landowners to enhance wetland habitats, DU has a head start in field experience. Said DU operations manager Rod Fowler: “We expect to be a major player in delivering habitat programs of the Plan.” Fowler is optimistic about the prospects for success, because the changes in farming practices needed for waterfowl are the same as those identified by agricultural experts as essential to maintaining soil quality.

The goal of waterfowl managers has a nostalgic ring: to restore the fall flights of 100 million waterfowl that were common in the 1970s. Whether that can be achieved may depend in part on success on global environmental issues, especially in curtailing the

atmospheric warming caused by the Greenhouse Effect. Canada's southern prairies are among the areas most at risk to global warming, and wetland habitats would clearly be affected by increased moisture loss. However, noted Patterson: "During the drought of

1988, areas with natural wetlands retained much more moisture, and those farmers benefited." Restoring natural habitats to the prairies, he hopes, will not only bring back the ducks, but make the land less vulnerable to climatic changes as well.¹

5. Give an explanation for the decline in duck populations from the early 1970s to today. In your explanation, you should list the causes for decline.
6. Why is the Waterfowl Management Plan a new approach to wildlife conservation? Explain how it works.
7. State the goal of waterfowl managers. What does the achievement of this goal depend upon?

Check your answers by turning to the Appendix, Section 2: Activity 3.

Have you ever seen cattails growing in a ditch or by a lake? Did you know that in the spring you can eat the young brown fruiting spikes like corn on the cob? You will be interested to read the following article on *Cattail Marshes – Nature's Cleansers*.

Cattail Marshes – Nature's Cleansers

by Sandra-Lee Konrad
DU Canada
Research Biologist

While the world searches frantically for answers to pollution problems, nature continues to quietly solve them as it has for thousands of years. Left alone, nature has the ability over time to balance and heal all but the worst insults to the environment. Wetlands and, in particular, cattails are important elements of nature's balance. They provide a distinctive environment that, when encouraged, can offer an economical method of waste water management.

In a cattail marsh, water is purified when the plants remove excessive levels of nitrogen and



COURTESY OF D. MERRILLS

¹ Ducks Unlimited Canada for the article taken from *Wetland Environments: Investigating the World of Waterfowl – A Science Curriculum Unit*. Reprinted with the permission of Ducks Unlimited Canada.

phosphorus. The source of nitrogen and phosphorus based compounds can be diverse. Fertilizers, manure, eroding top soil, domestic sewage or industrial discharge can all be sources. Unchecked, chemical nutrients can stimulate algae growth, choking waterways and eventually creating nuisance odours, lowered oxygen levels and stagnant water conditions that encourage disease.

Cattails are persistent inhabitants of fresh to brackish waters, abundant in temperate, sub-tropical and tropical climates. They develop networks of roots, sometimes forming vast colonies from a single individual plant. During their maximum growth period, cattails will quickly absorb high levels of nitrate, ammonia and phosphate. As the stand grows more dense, it absorbs more nutrients. In three weeks of such rapid growth, the plants can remove up to 90 percent of the nitrogen and phosphorus in raw sewage. Eventually, under the right conditions, purified water is the result.

During autumn the perennial cattail begins to store sugars and starch in its roots system for early growth in spring. As a result, all but the root system withers and dies. The dead plant material

houses nutrients extracted from waste water and in the normal course of events, many of these nutrients would return to the system as detritus. In a managed waste water marsh, excessive nutrients can be removed by harvesting the plants before they wither.

A natural harvest is provided by some marsh residents. White-tailed deer eat leaves and shoots, while muskrat, beaver and certain waterfowl will feed on the tubers and roots. Cattails have also been used to provide emergency forage to livestock in drought years. Cattail diets have been demonstrated to produce satisfactory weight gain in both sheep and cattle.

Though the cattail's ability to purify waste water has only recently been recognized by humans, the plants have long been used in other ways. Early in spring the young fruiting spikes can be roasted and eaten like corn on the cob and lower stem and roots are used in salads. Mature roots can be pounded into cattail flour that contains more protein than corn or rice flour but slightly less than wheat or potato flour. The dust-like seeds, about a quarter of a million on a single 17-centimeter spike, can produce

cooking oil similar to sunflower oil or a drying oil similar to linseed oil.

It is possible to harvest the mature plant and waste none of it. Fibres from the fuzzy seed spike can be spun into a fabric with qualities similar to parachute silk, or used as insulation in clothing or in buildings. Stems of the cattail yield adhesives that can be used for sizing paper and smoothing agents for facial and shaving creams. Leaves can be used for weaving and leaf fibres can be used for making string, burlap-like products, webbing, and furniture stuffing. Even ethyl alcohol can be distilled from cattails.

Perhaps if some of the more subtle virtues of cattails were better known, the plants would become more common in urban areas where people often mistakenly associate them with stagnant or dirty water. Not only do cattails clean water, but they can actually keep algae growth down by shading the water from the sun and preventing overheating. Last but not least, cattails produce a natural insecticide that, contrary to what most people might believe, will actually discourage the production of mosquitoes in a healthy wetland.¹

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

8. Give four reasons why cattails are important elements of nature's balance.

Check your answers by turning to the Appendix, Section 2: Activity 3.

You should now appreciate why wetlands are the most productive ecosystem in the world and also their importance in the overall balance in the biosphere.

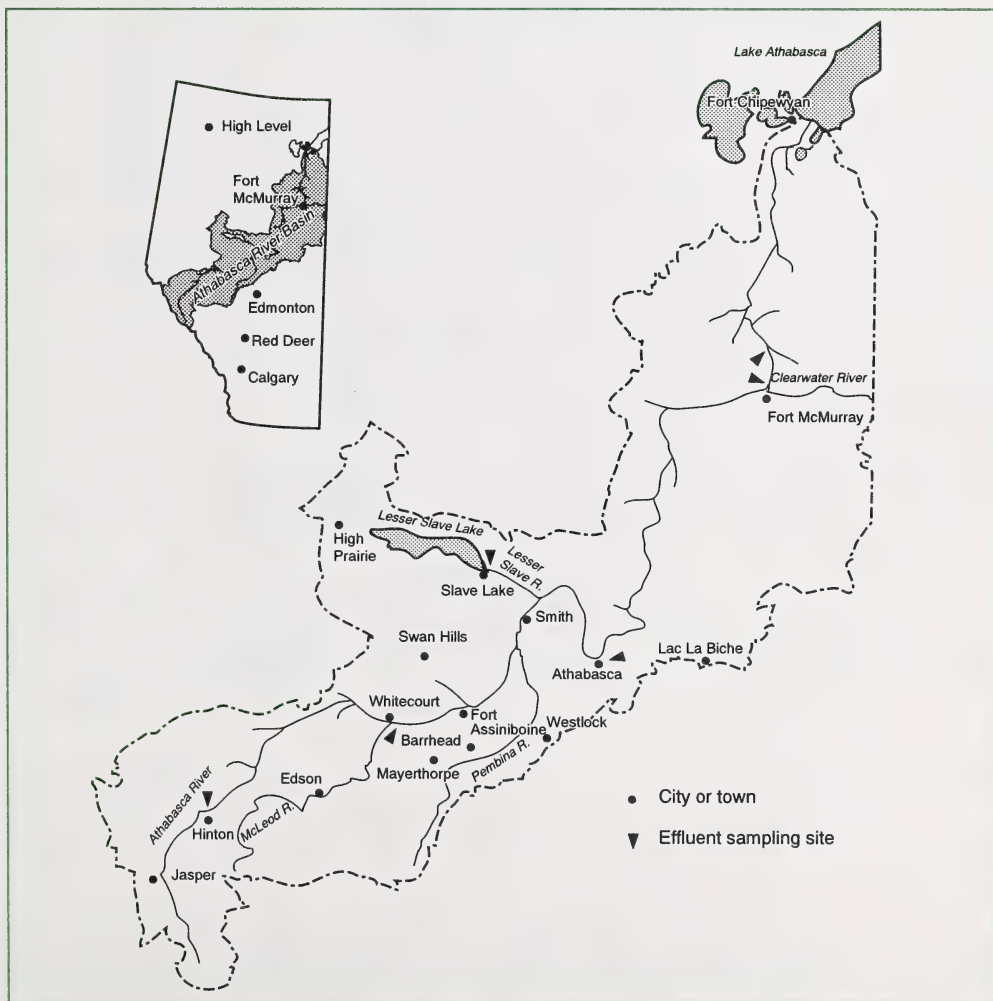
¹ Ducks Unlimited Canada for the article taken from *Wetland Environments: Investigating the World of Waterfowl – A Science Curriculum Unit*. Reprinted with the permission of Ducks Unlimited Canada.

ACTIVITY

4 The Athabasca – A Case Study

Have you spent time walking along a river? Can you imagine the sound of water bubbling over the rocks, fish splashing, or water fowl flying by? Can you appreciate the earthy smell of damp shorelines or the bright colours on hillsides in autumn? Alberta's rivers are an important part of provincial wetlands.

The Athabasca River forms Alberta's largest river system. It flows from the mountains in Jasper National Park to Lake Athabasca in the north-eastern corner of the province.



The many ecosystems along the Athabasca River depend critically on the quality of the water. Pollution of this large body of flowing water may have a drastic effect on plants and animals along its length. It also would affect a wide range of human activities.

Beside depending on the river, human activities affect the river itself. At the present time, pulp mills along the Athabasca River threaten to have a major impact. People are concerned. As a student of biology with knowledge of ecosystems, you should be able to understand this conflict. One way or the other you'll learn more about the world you live in.



Watch the video *The Athabasca: A Case Study* to examine the strong opposing views. Answer questions 1 to 10.

dioxin – TCDD, a by-product formed when making 2, 4, 5-T herbicide and when burning chlorine compounds

uran – a water-insoluble compound occurring in wood oils and seed husks. Some urans are used in bactericides.

Science Skills

- ☐ A. Initiating
- ☒ B. Collecting
- ☒ C. Organizing
- ☐ D. Analysing
- ☐ E. Synthesizing
- ☐ F. Evaluating

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☒ E. Synthesizing
- ☒ F. Evaluating

- Several people contributed their views on the location of a pulp mill near the town of Athabasca. Create a pro (for building) and a con (against building) list for the participants and briefly state the points of view of each one. You may find that many do not fit into the pro/con classification. In these cases they should be placed in a group called Caution/Undecided. The participants are Dr. Woodrow Morrison, Larry Duniece, Sue Lysyk, Louis Schmidtroph, Leigh Noton, Judy McElligott, Jeanette Plante, Laudy Lickacz, Dr. Steve Hrudy, Rebecca Hutchinson, and Niki Stady.
- Name five factors that affect water quality. Name the units used to express these factors.
- Of the five factors that you listed, which one is the most vital to aquatic life and how is it added to the water?
- Explain why the water quality in winter is so important.
- What is BOD (Biochemical Oxygen Demand)?
- Explain what a high BOD value means.
- What were the three objectives set out by Alberta Environment in their studies on the Athabasca River?
- Dioxin** and **uran** were two toxic substances missing from the list of substances tested for in the river samples. Why do these substances spark such controversy?
- The Athabasca River Basin is shown at the beginning of this activity. Can you identify the sites along the river where effluent release could change the water quality? Look for three major sites and a group of smaller ones.
- The Athabasca and Peace River systems form the main drainage basins for over half of Alberta. With this in mind, along with what you have viewed in the video, would you be in favour of building another pulp mill on the Athabasca River? Explain your answer.

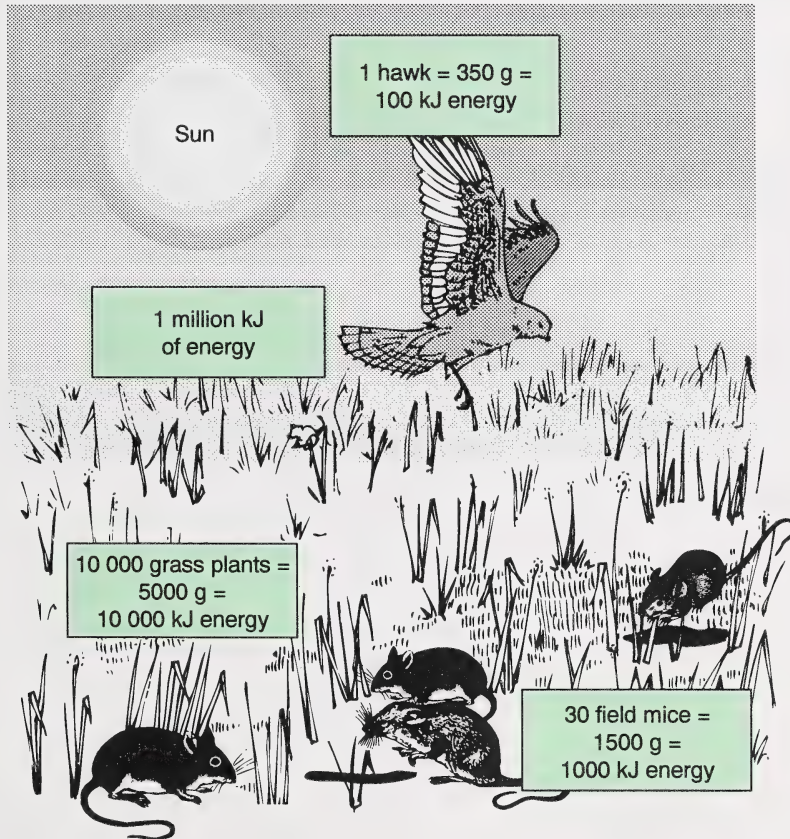
Check your answers by turning to the Appendix, Section 2: Activity 4.

Follow-up Activities

If you had difficulties understanding the concepts in the activities, it is recommended that you do the Extra Help. If you have a clear understanding of the concepts, it is recommended that you do the Enrichment.

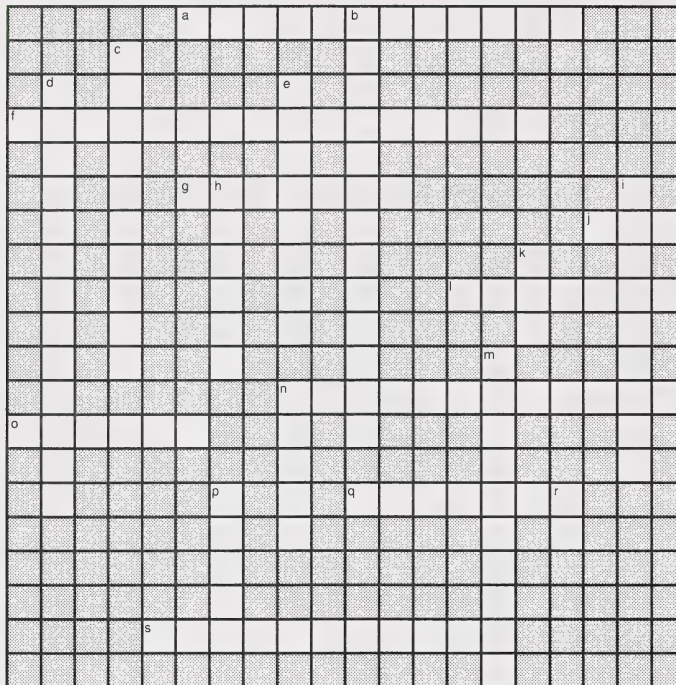
Extra Help

1. Examine the following diagram and answer the questions that follow.



- a. Describe the flow of matter and energy through this food chain. Include a circular pathway using decomposers.
- b. Construct a pyramid of numbers based on this ecosystem.
- c. Construct a pyramid of biomass based on this diagram.
- d. Construct a pyramid of energy based on this diagram.

2. Complete the following crossword puzzle using terms and clues from this module and your text.



Across

- a. amount of increased biomass
- f. the build-up of toxic chemicals in organisms along a food chain
- g. area of land partially covered by water for at least part of the year
- j. short for polychlorinated biphenyl
- l. total amount of living and dead material in an area
- n. wide variety of species of organisms
- o. by-product formed during the preparation of herbicide 2, 4, 5-T
- q. a structure where the amount decreases in rising layers
- s. the growing of a single species of plant in an ecosystem

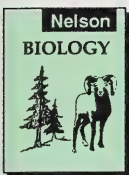
Down

- b. amount of a substance in a given space
- c. an inherited change in an organism that increases its chances of survival
- d. a microscopic living thing
- e. general term for waste fluid from manufacturing and farming
- h. abiotic compound provided by the sun
- i. a community and its chemical and physical environment
- k. amount of oxygen used by living things
- m. an organism that causes decay
- n. a large scale ecosystem such as tundra or grassland
- p. a compound in wood oils sometimes used in manufacturing bactericides
- r. amount of oxygen dissolved in water at a given temperature

Check your answers by turning to the Appendix, Section 2: Extra Help.

Enrichment

Do any or all of the following.



1. Read pages 63 to 65 in your text and do the following:
 - a. Turn to the Enrichment Activities on page 65 of your textbook and do textbook question 1.
 - b. Turn to the Enrichment Activities on page 65 of your textbook and do textbook question 2.
 - c. Write a response to the statement: "Protecting the environment should have priority over economic interests."
2. Wetlands, as you saw from Activity 3, are not only the most productive ecosystem, but they seem to be the most endangered on a global basis. Find out what is being done about wetlands in Alberta by writing to the following address:

Environment Council of Alberta
 4th Floor, 9925-109 Street
 Edmonton, Alberta
 T5K 2J8
 Phone (403) 427-5792
 Fax (403) 427-0388

Ask for the publication *Alberta's Wetlands:
 Water in the Bank!*

You can also write the North American Waterfowl Management Plan office in Edmonton and ask for information pamphlets and posters. Use this address:

North American Waterfowl
 Management Plan Centre
 Room 401, East Tower Coronation Plaza
 14310-111 Ave.
 Edmonton, Alberta
 T5M 3Z7

Write a report which takes into account the regulatory aspect of wetlands (legislation), the locations and status of wetlands in Alberta, and the economic and social benefits and overall benefit assessment of wetlands.

3. Have a number of friends and family watch the video *The Athabasca: A Case Study* with you. Get them to write down their opinions on whether a new pulp mill should be built on the Athabasca. Discuss these opinions in a group and come to some consensus on this question.

Or, take the question to friends and community members where you live and explain the situation to them using the Athabasca River Basin map. Ask them to give their opinion on this question.

4. Write to Ducks Unlimited and ask them for pamphlets on waterfowl that inhabit the wetland habitats of Alberta. Also ask them for information regarding their Preserve, Restore, and Enhance Projects. Mention in your letter that you have viewed the video *If You Build It* and would be interested in further information. Put this information in a journal to which you can add any recent newspaper or magazine articles on the wetlands. By staying informed, you can help ensure that wetlands will have a good chance of remaining a part of dynamic ecosystems. Here is a possible design.

Wetland Journal		
Date	Key Information	Action Required (letter, phone, etc.)
Write to the following address: Ducks Unlimited Canada #202 10470-176 Street Edmonton, Alberta T5S 1L3		

5. Write to the public relations office of Ducks Unlimited at Oak Hammock Marsh in Manitoba. Ask for information on the Greenwing Program and for the pamphlet *More Than Just Ducks*.

Use this address:

Ducks Unlimited Canada
P.O. Box 1160, Oak Hammock Marsh
Stonewall, Manitoba
R0C 2Z0

Conclusion

In this section you learned how to graph data pertaining to pyramids of energy, biomass, and numbers in ecosystems. You also learned about the impact humans have had on these ecosystems with activities such as monocultures. Monocultures must work in harmony with existing ecosystems if both are to benefit. You also learned about the most biologically productive ecosystem – wetlands – and discovered how important it is that this ecosystem be preserved, restored, and enhanced. Finally, you saw the impact of the proposed construction of a pulp and paper mill on the Athabasca River.

Section 2 Assignment: Human Impact

Review the Evaluation information found in the introductory pages of this module.

It is important to number and clearly identify each page with the following information at the top:

Biology 20 – Module 3

Section 2 Assignment

Page #

Name and ID#

Be sure to write legibly. Leave a wide left margin and number all of your pages.

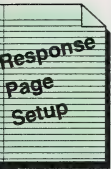
1. a. Explain why there is always a loss of energy with each step in a food chain. **(4 marks)**
 b. What natural law does this illustrate? **(3 marks)**
 c. What structure is created by this process? **(3 marks)**
2. Of the three types of ecological pyramids – biomass, numbers, and energy flow – which one is **always** shaped like a real pyramid, with the largest amount in the producer level? Explain fully. **(10 marks)**
3. Humans have had a great impact on ecosystems throughout the world. Provincially, the building of pulp and paper mills has caused much controversy.

Write an essay which discusses the pros and cons of locating a pulp and paper mill on the Athabasca River. You should include in this consideration the ecological, economic, and social issues related to this question. **(10 marks)**

Reproduce the science skills assessment box after your response to this question. Remember to indicate your evaluation of your skill level for each identified science skill. Be sure to include the spaces for teacher assessment.

Self:	A. ☐	B. ☐	C. ☐	D. ☐	E. ☐	F. ☐
Teacher:	A. ☐	B. ☐	C. ☐	D. ☐	E. ☐	F. ☐

4. Wetlands are among the world's most productive ecosystems. Describe the environmental and economic value of wetlands in Canada today. **(10 marks)**
5. One factor that must be managed in monocultures is the density of plant growth. The following graph shows Yield (tonnes/ha) versus Plant density (per m²) for corn plants. With reference to the following graph, explain why the rate of cob dry mass production by each remaining plant is reduced as the plant density increases. **(10 marks)**



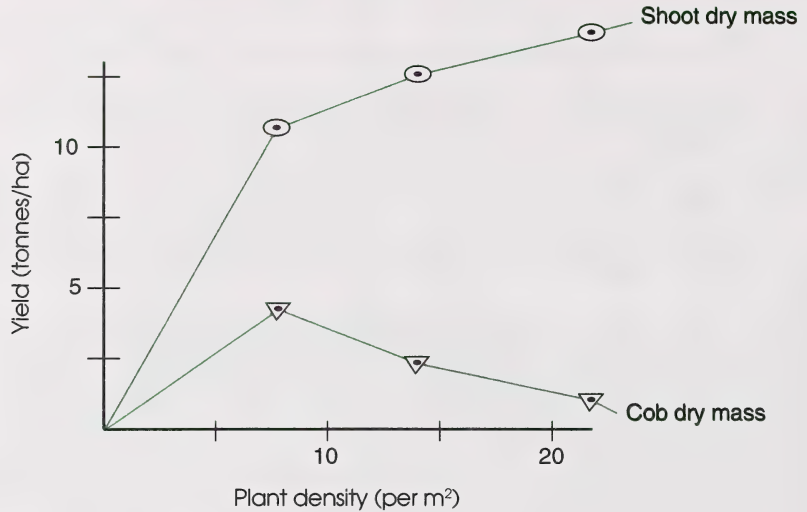
Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☐ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

Science Skills

- ☐ A. Initiating
- ☐ B. Collecting
- ☐ C. Organizing
- ☒ D. Analysing
- ☒ E. Synthesizing
- ☐ F. Evaluating

THE EFFECT OF PLANT DENSITY ON DRY MASS OF COBS AND SHOOTS IN CORN



Reproduce the science skills assessment box after your response to this question. Remember to indicate your evaluation of your skill level for each identified science skill. Be sure to include the spaces for teacher assessment.

Self: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐
Teacher: A.	☐	B.	☐	C.	☐	D.	☐	E.	☐	F.	☐

MODULE SUMMARY

You have examined ecosystems and you have seen how energy flows through them. Now you can understand why it is important to remain on the marked trails when hiking in the mountains. Higher mountain ecosystems are very delicate indeed. It takes many decades for plants to become well established in a given area. A hiking boot not only can crush a plant, but it can also disrupt a part of this ecosystem.

On a larger scale the impact that humans have on the environment can be experienced locally. This was the case when you examined the effects of reclaiming wetlands and monoculturing practices. Human impact was also seen when decisions to build pulp and paper mills on the Athabasca River were examined and looked at critically.

Many people are concerned that global warming, the disappearing ozone layer, and the destruction of the tropical rain forests in the Amazon eventually touch all living things. You can see that events that happen in one part of the globe very soon are experienced in other parts of the globe, seemingly remote from the original event.

You should now have a deeper understanding and appreciation for local ecosystems and ecosystems in other parts of the world. They all function by the same principles involving the flow of matter and energy.

To ensure that all of your work has been completed in a satisfactory manner, check off the items in the following list:

- ☐ Section 1 Assignment has been completed.
- ☐ Section 2 Assignment has been completed.
- ☐ Your responses are organized and neat, with room for teacher comments.
- ☐ All your response pages are numbered consecutively and identified with this heading.

Biology 20 – Module 3

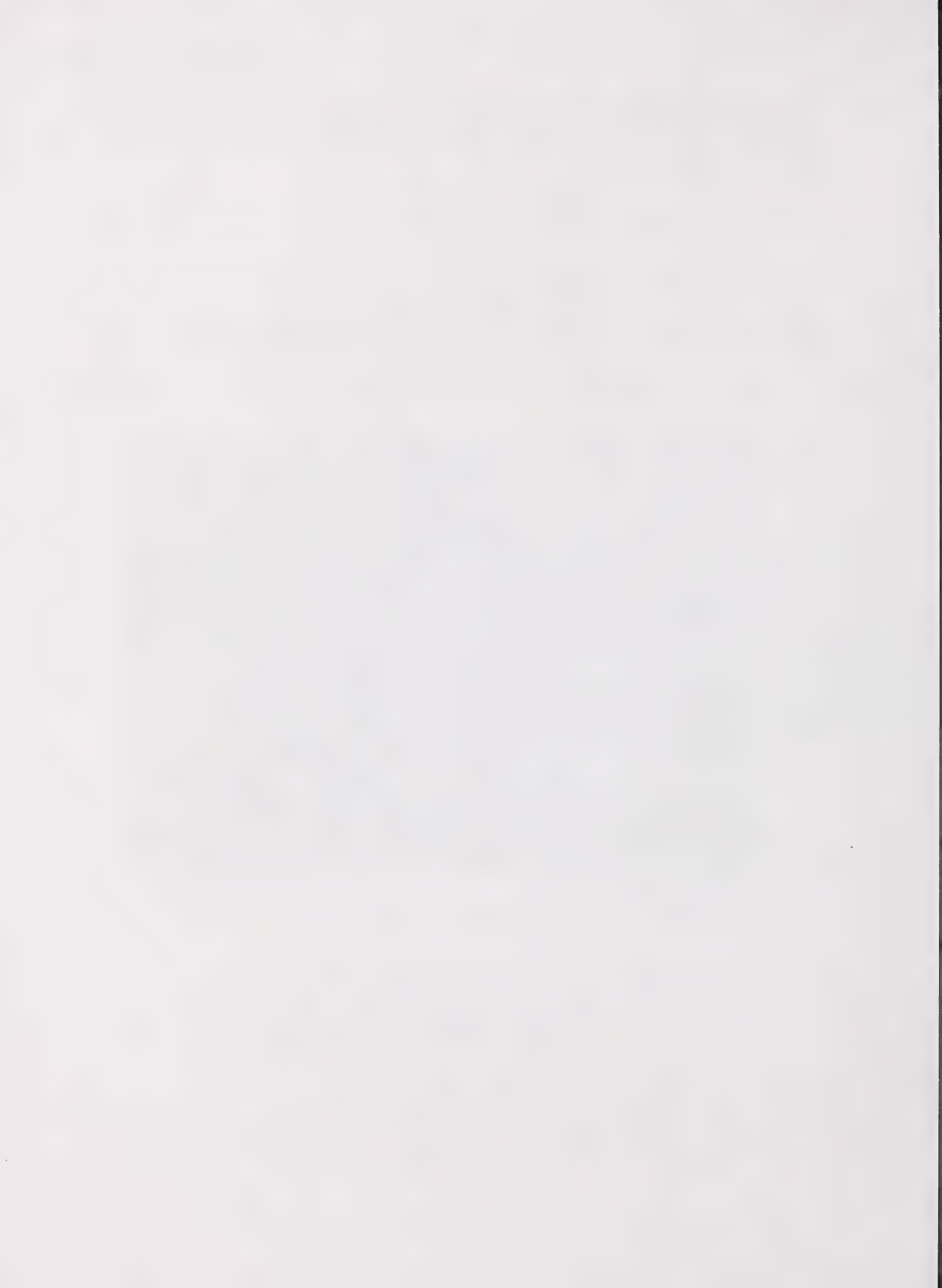
Section # Assignment

Page #

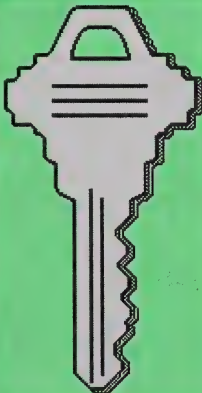
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COURTESY OF D. MERRILLS



Appendix

	Glossary
	Activities
	Extra Help
	Enrichment

Glossary

arbitrary: simply established to create a point of reference

biological amplification: the increase in concentration of a substance in the bodies of living organisms along a food chain; also called bioamplification

biological diversity: numerous different species living in an area; also called biodiversity

calorimetry: the measurement of the amount of heat energy in a substance

combustible: can burn or support burning

dioxin: (2, 3, 7, 8-tetrachlorodibenzo-p-dioxin, TCDD: $C_{12}H_4Cl_4O_2$) . . . a by-product formed during the preparation of the herbicide 2, 4, 5-T, and sometimes produced by the incineration of chlorinated organic compounds

effluent: waste products from industry or agriculture

furan: (C_4H_4O) . . . a compound fairly insoluble in water, but readily soluble in alcohols, ether, and acetone, belonging to a group of organic compounds (furans) that occur naturally in wood oils, seed husks, and other plant materials

Furans, especially furfural (C_4H_3OCHO), are used as bactericides and in the manufacture of perfumes and flavourings and in synthetic fibres. Furans are toxic to humans.

monoculture: a single species of plant grown in an area

reclamation: restoring the biotic and abiotic factors of an ecosystem

self-sustaining: capable of maintaining communities and populations naturally over a long period of time

stability: resistance to change

toxin: a poisonous substance

Suggested Answers

Section 1: Activity 1

HUMAN BODY		ASPEN PARKLAND	
Level	Example	Level	Example
cell	muscle cell, skin cell, blood cell, fat cell, nerve cell	organism	deer, grass, trees, ground squirrel
tissue	muscle tissue, nerve tissue, blood	population	deer, squirrel, grass, and tree populations
organ	heart, brain, eye, liver	community	deer and grass, squirrels and trees, all populations together
organ system	circulatory, digestive, immune, nervous, reproductive	ecosystem	biotic and abiotic components: soil, air, water, grass, deer, squirrels, trees
organism	you	biosphere	living world

2. An ecosystem, made up of biotic and abiotic components of the environment, is a functional unit of the biosphere. The biosphere contains many combinations of biotic and abiotic components and so has many different kinds of ecosystems.

3. The biotic factors are all living factors such as plants and animals; e.g., poplar and birch trees, voles, and insects.

The abiotic factors are all nonliving factors such as chemical and geological factors; e.g., rocks and minerals and physical factors such as temperature and weather.

4. The boundaries of an ecosystem are determined by the ecologists who study them.
5. Boundaries may be less distinct because the organisms tend to move into and out of defined areas during their daily activities.
6. Energy is the most important driving force of an ecosystem and it is integrated into the biosphere through photosynthesis and the feeding activities of non-photosynthetic organisms.
7. If the fish is kept, it represents matter that is taken out of the ecosystem. Stored energy is also being removed. If it is released, perhaps due to size regulations, then the amount of matter remains unchanged.
8. Ecosystems are not always self-sustaining because energy and matter can enter and leave. Ecosystems do not have rigid boundaries; therefore, organisms need not spend all of their life within one ecosystem.
9.
 - a. Water is the world's greatest natural **resource**. Approximately **70%** of the human body is water. Water covers **2/3** of the planet. Oceans control **the weather** patterns on Earth. The greatest portion of fresh water is stored as **snow and ice**.
 - b. Water can be used to extinguish fires but contains **hydrogen** and **oxygen**, two highly combustible gases. A water molecule attracts other molecules, including **itself**. Water **expands** when cooled to form ice. Water is a **solvent** and as such is rarely found in its pure form in nature. Other molecules (such as oxygen in lakes and streams and minerals, vitamins, and sugars in the blood of animals) dissolve readily in it. Water has the ability to store heat and therefore moderate **climate**.
10.
 - Textbook question 1: Aquatic ecosystems are more stable in terms of matter entering and leaving. There is a greater opportunity for matter and energy to enter and leave terrestrial ecosystems. Also, there is less temperature fluctuation in an aquatic ecosystem. Bodies of water slowly warm but also slowly cool; so they tend to store energy.
 - Textbook question 2: Freshwater and marine communities are distinguished on the basis of the amount of dissolved salts there are in each. The amount of dissolved salts (soluble minerals) is lower in freshwater and higher in marine environments.
 - Textbook question 3: In a pond, light penetrates to the bottom and therefore photosynthesis occurs throughout the pond. In a lake, light will not penetrate to the bottom and hence, there is a region in which photosynthesis cannot occur.
 - Textbook question 4: Brackish water is found where freshwater rivers and streams flow into saltwater oceans and seas causing a mixture that is intermediate in salt concentration between fresh and salt water.
 - Textbook question 5: Temporary standing water is water collected in temporary sites which range in size. The duration of this standing water is dependent upon local precipitation, the melting of snow and ice, and evaporation.

- Textbook question 6:

OLIGOTROPHIC LAKE	EUTROPHIC LAKE
• deep and cold • large bodies of water • nutrient levels low, limited producer activity • water usually clear, bottom visible at great depths • little change over time	• shallow and warm • relatively smaller • nutrient levels are high, producers very active • water not clear, bottom not usually visible • great changes over time

- Textbook question 7: Some major causes of eutrophication are the addition of human wastes, fertilizers (in the runoff from agricultural land), and various household and industrial products to the water system.

11. Ecosystems have the following features:

- are the fundamental units of ecology
- consist of communities of plants and animals interacting with each other and their surroundings
- are physically and biologically distinct regions
- vary in size and complexity and merge into one another
- are influenced by adjacent ecosystems
- process energy by the biotic components of each ecosystem

12. Tropical ecosystems are more complex and therefore can absorb change. This increasing complexity leads to stability, since adjustments to change can be made. On the other hand, arctic ecosystems represent a simpler ecosystem, so loss of one species can be detrimental. Thus, simpler ecosystems are less stable.

13. Five examples are listed and explained here. Your responses may be somewhat shorter, but should contain the following relevant ideas. Five examples of human intervention include weather modification, fire, reforestation/scarification, biological control of mosquitoes, and water treatment.

Weather modification occurs on the abiotic level, where silver iodide crystals are released into clouds reducing the size of hailstones. The benefit is prevention of excessive hail damage. The risks would probably only involve the pilot of the seeding aircraft.

Fire as a controlled burn may benefit some ecosystems by causing the release of seeds to populate the newly created environment. The risks might involve destruction of abiotic interactions that possibly may not recover to the original state for a long time. For example, a controlled burn that clears surface vegetation may create spaces for new plants. However, too great a fire may consume all organic material in top soil and require many years for regeneration. Fire is abiotic, but its effect, or the response to fire, is biotic.

Reforestation/scarification is both biotic (trees) and abiotic (soil) in its impact. The benefits are to loosen the soil and expose it to the atmosphere. This will allow new organisms to move into the soil. The risks, although minimal, may be the disturbance of the ecosystem in terms of soil species. Scarification is also very disruptive, making the land quite unsuitable for recreation.

Agriculture Canada in Lethbridge is using a fungus to infect the larvae of mosquitoes to biologically control the population. This is clearly a biotic intervention and the benefit would be control of the mosquito population without affecting other organisms in the ecosystem. The risk would occur if the fungus invaded other species and did not behave as it did under laboratory-controlled conditions. The fungus represents a newly introduced species in the ecosystem and will become a part of the flow of water and energy.

14. Water is of key importance to all ecosystems. Energy is also important.
15. Phosphates greatly increase the process of eutrophication. With their reduction, algae and other aquatic plants would be less likely to bloom and overpopulate the ecosystem. Reducing phosphates would reduce plant growth and the amount of decaying plant material created when plants die. Decay uses oxygen. Less decay means more oxygen for fish and other animals.
16. pH of normal rain = 5.6; pH of acid rain = 2
17. Tar sands plants, gas plants, and vehicles all contribute to acid rain in Alberta.
18. Reclamation mainly centres around water and the treatment of water and its replacement into the original ecosystem in an unaltered form. The problem is that water is only part of the ecosystem. All of the critical interactions that take place within the ecosystem would be lost and would be impossible to replace. Reclamation, therefore, is a way to make the general public feel that what is being done is for the benefit of all and in particular, the environment.

Section 1: Activity 2

1. a. autotrophs: organisms that can synthesize their own food material from photosynthesis or by some other chemical means

heterotrophs: organisms that cannot synthesize energy for their own use; they feed on other organisms to meet these needs

producers: organisms that use photosynthesis or chemosynthesis to meet their energy needs; they are usually plants

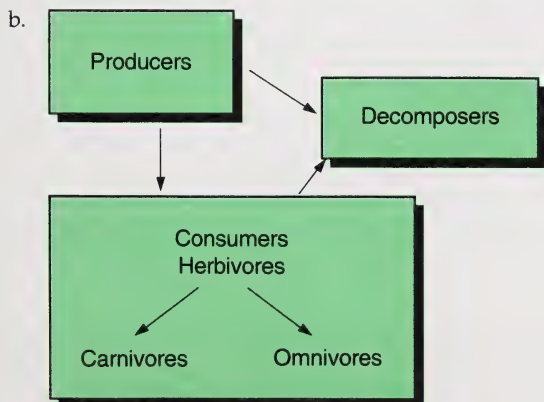
consumers: organisms that feed on other organisms to meet their energy needs

decomposers: organisms that break down dead organic matter into simpler compounds, e.g., bacteria and fungi

herbivores: organisms that feed on producers to meet their energy needs

carnivores: organisms that feed on other organisms to meet their energy needs

omnivores: organisms that feed on producers or other consumers to meet their energy needs



2. The role of decomposers is to return matter and energy contained in dead and decaying organisms to the ecosystem for reuse. They are the recycling plants of the ecosystem.
3.
 - a. A food chain consists of a number of organisms which form a series through which energy is passed. Producer organisms are at the base of the chain followed by consumers. First-order consumers, or herbivores, feed on the producers; second-order consumers feed on the first-order consumers, and so on.
 - b. A grazer food chain follows the pattern described in 3. a., whereas a decomposer food chain operates at all food chain levels.
4. Trophic level refers to the position or level of an organism in a food chain during its energy-seeking activities. At the base of the food chain are the producers of the first trophic level. Producers trap energy from sunlight in photosynthesis and they are also autotrophs. This energy is available for the consumers. The second trophic level is represented by herbivores, or organisms that obtain their energy from the producers occupying the first trophic level.
5. Omnivores are organisms that obtain their energy from either plants or animals. They occupy the consumer category of the food chain, e.g., badger, humans, etc.

Carnivores are organisms that eat other animals to meet their energy requirements, e.g., polar bear, osprey, etc.

Herbivores are organisms that obtain their energy by feeding on plants exclusively, e.g., cow, krill, etc.

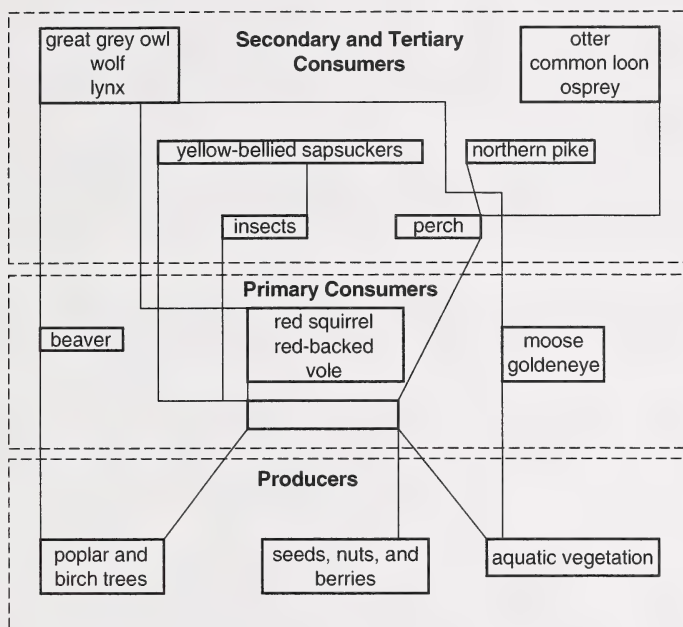
6. The following are possible responses:
 - aquatic vegetation → moose → wolf
 - poplar tree → insects → red-backed vole → great grey owl
 - aquatic vegetation → insects → perch → northern pike → osprey
 - poplar and birch trees → beaver → wolf
 - seeds, nuts, and berries → insects → yellow-bellied sapsucker → great grey owl

Other responses are possible.

7. Food chains represent the flow, or transfer, of energy from one trophic level to another. Food webs represent a number of interconnected food chains representing energy transfer through various levels in an ecosystem.
8. Food webs can be quite complex. They may change with the seasons. Trophic levels are not always obvious when viewing an ecosystem. Entire populations may not be visible and interactions between organisms may be subtle or may not be occurring at the time of observation. As a student of biology, you should be able to recognize several good possibilities in the Northern Forest ecosystem illustration. Look for producers and consumers. Also look for autotrophs and heterotrophs. Watch for predators and prey. Notice relative numbers of organisms (biomass). There is only one otter in the illustration. It may be near the top of a food pyramid along with organisms like the wolf and lynx. Notice all the vegetation. This makes up the producers. Much of this vegetation is food for other organisms, such as moose, beaver, and squirrels. They in turn provide food for consumers on the next level. A possible food chain could go from aquatic vegetation to perch to osprey. The otter may also eat perch. Ducks may lunch on aquatic vegetation. As the food chains intertwine, they form a complex food web. Levels form each time energy or matter is transferred.

As a student of biology, you can make a food web as simple or as complex as you like. As previously described, start by placing organisms in successive trophic levels. Next connect the organisms to form food chains. Lines will probably cross. This forms the food web. Food webs are useful in that they may indicate the wide spread effect on the ecosystem if a single organism is removed. Look at this example.

NORTHERN FOREST FOOD WEB



9. Dieldrin nearly eliminated malaria, which is carried by a mosquito. Other insects, such as wasps were wiped out. Lizards that fed on the insects died off. Domestic cats feeding on the lizards got sick and died. The rat population increased as a result. The caterpillar population also increased due to lack of predation by wasps. The caterpillars devastated food crops and fed extensively on leaves used to thatch roofs.
10. Biological amplification refers to the accumulation of toxins in food chains. As the toxin progresses through the food chain, its concentration increases in the trophic levels containing fatty tissues which store it. Thus, the top carnivores accumulate the greatest concentrations of the toxins in question. While digestive systems can accumulate toxins and store them in the body, no system exists to excrete the toxins.
11. Migratory birds such as the mallard duck, Canada goose, and peregrine falcon winter in Central America and Mexico where DDT is still used. The migrating fish in the Atlantic and Pacific Oceans are affected in a similar way due to run-off from the land where DDT is used. This DDT gets into the food chains and food webs when these species migrate northward again, thereby passing this toxin throughout northern food chains and webs.
12. Through the process of biological amplification, the fish in the aquatic ecosystems near the effluent-release sites are experiencing an increase in toxin levels to the point where they cannot be consumed by humans and more to the point, it is affecting other top carnivores (birds) that consume the fish. This irresponsible dumping of chemicals by the named companies must be stopped if the aquatic ecosystems are to be maintained. This would represent the backbone of the report – individual answers will vary.

Section 1: Activity 3

1. An ecological pyramid is a graphical representation of energy flow in food chains and webs. Due to energy loss fewer organisms can be supported at each additional level in a food chain. The base of the pyramid represents the fixed energy available and the remainder represents what happens to this energy.

2. Pyramid #1: A Pyramid of Numbers

This is the least accurate. In this graph, the numbers of plants and animals in each trophic level are counted. This is least accurate, since one large producer can support a larger number of herbivores feeding on it.

Pyramid #2: A Pyramid of Biomass

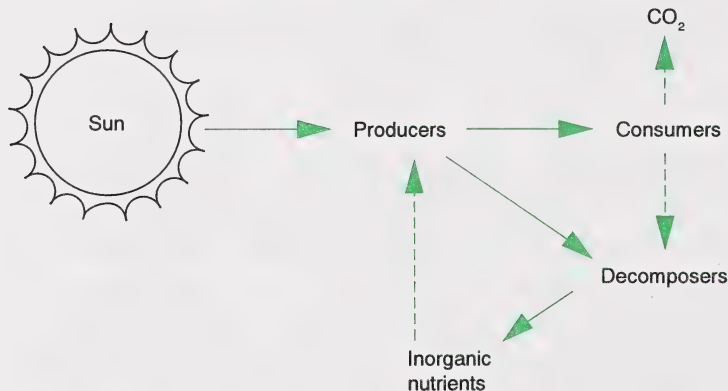
This more accurately represents the energy flow in this food chain/web. This graphical representation measures the mass of the dry tissue in the plants and animals. Thus, decreases in energy use are more accurately seen.

Pyramid #3: A Pyramid of Energy

This is the most accurate way to determine energy loss in a food chain/web. The chemical bonds making up organic molecules contain large amounts of stored energy. By burning organic matter and measuring the amount of heat given off, a measure of the energy contained in the matter can be determined.

3. The producers at the first trophic level are able to capture the most energy. They are autotrophs which capture energy from the sun and convert it through photosynthesis into chemical energy in carbohydrates.

4. MODEL ECOSYSTEM



5. In an aquatic ecosystem the producers will be aquatic plants and algae. Consumers will be plankton, insects, and perhaps small fish feeding as herbivores. Higher levels of consumers will be larger fish and fish-eating animals. Energy will flow through producers and consumers to decomposers. Decomposers will include bacteria and fungi in the water and on the bottom. A terrestrial ecosystem model will have very similar trophic levels but different types of organisms at each level. For example, grasses, shrubs, and trees would take the place of algae and aquatic plants. Consumers would still include herbivores and carnivores. Decomposers would be bacteria and fungi.

Section 1: Follow-up Activities

Extra Help

1. An ecosystem is a defined area of the environment in which biotic and abiotic factors interact.

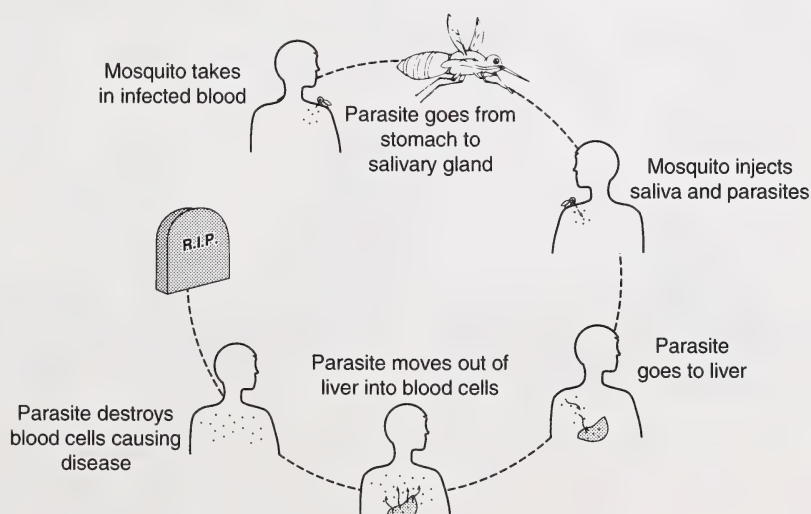
2. Biotic factors are living factors of the environment such as a birch tree, algae (producers), a fox, or paramecium.
Abiotic factors are nonliving factors of the environment such as soil type, wind, or available moisture.
3. Biotic and abiotic factors are important because it is their dynamic interaction that allows an ecosystem to function effectively, that is, it is balanced.
4. a. Producers are autotrophic organisms (plants) that are able to synthesize their own food through the process of photosynthesis.

Consumers are organisms that must eat other organisms for their survival. They cannot synthesize their own food.

Decomposers are organisms that rely on dead or decaying organic matter to meet their energy needs.
- b. Producers = spruce tree, grasses, mosses
Consumers = insects, frogs, hawks
Decomposers = bacteria (many species) and fungi (many species)
5. Food chains represent the order of trophic (feeding) levels in an ecosystem; for example, seeds, mice, owls. Food webs are a series of interconnected food chains present in an ecosystem. For example, seeds might be eaten by mice and insects; mice might be eaten by hawks, owls, and foxes.
6. An aquatic ecosystem has a definite boundary delimited by the water itself; a terrestrial ecosystem has a less definite boundary which is defined by the ecologist studying it. Vegetation in an aquatic ecosystem is unique in that there are submergent, emergent, and floating vegetation (plants); terrestrial ecosystems have plants which range from grasses to mature trees. Both ecosystems are similar in that their underlying trophic structure consists of producers, consumers, and decomposers.

Enrichment

1. Individual answers will vary depending upon the biome chosen for study.
2. Refer to the life cycle diagram that follow.

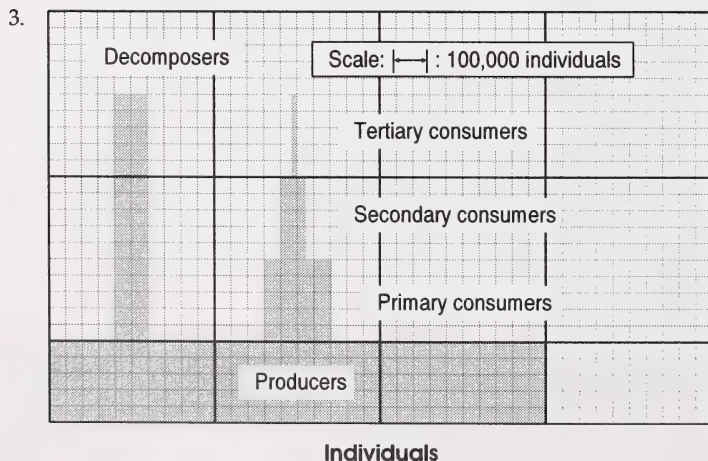


Bird malaria will follow the same life cycle that human malaria does.

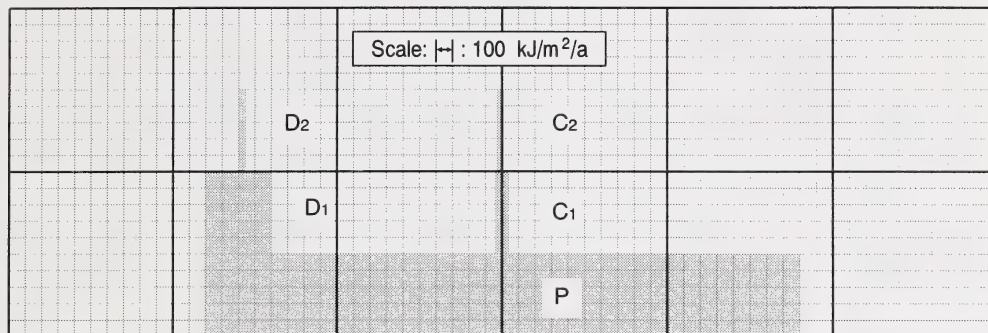
3. Individual answers will vary depending upon the biome chosen for study.
4.
 - Textbook question 1: The data shall show that a temperature increase occurs below the snow pack close to the ground.
 - Textbook question 2: Individual student results should show
 Site 1 (Midpoint – T_2) – colder than T_3
 Site 2 (Snow-ground interface – T_3) – warmest location
 - Textbook question 3: Yes, with no snow cover the temperatures would be the same as air temperature (approximately) because the insulating effects of the snow are no longer present.
 - Textbook question 4: No, the air temperature would reflect ground level conditions, provided there was no warming effect from the sun.
 - Textbook question 5: This is an excellent survival mechanism. The snow will form an insulating blanket over you and you will not experience the colder surface temperatures.
5. For an answer to Critical-Thinking Question 5, contact your nearest Fish and Wildlife office.

Section 2: Activity 1

1. Three types of ecological pyramids are numbers, biomass, and energy.
2. The most valid is the pyramid of energy since it relates to the productivity of the ecosystem. The pyramid of numbers is the least valid representation of measuring the flow of energy since a great number of aphids could feed from a single apple tree. The greater amount of energy is contained in the tree but in terms of numbers it is represented by one.

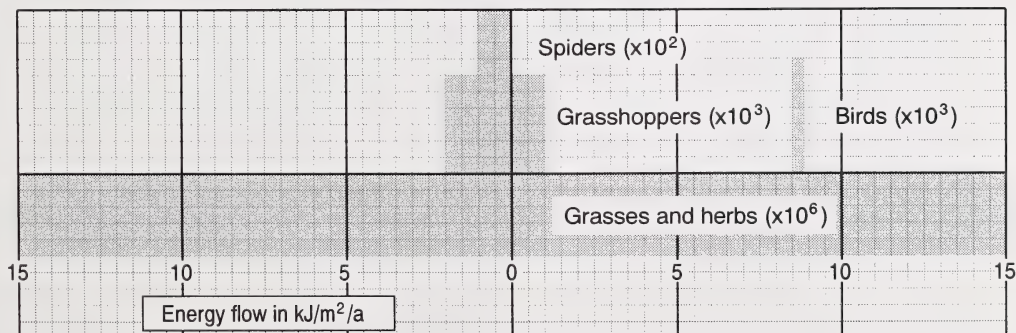


4.

Energy in $\text{kJ/m}^2/\text{a}$

5. The organisms at each trophic level lose energy through heat, respiration, and elimination. Their overall structure, therefore, contains less energy than the food which entered their bodies. In addition, many organisms or parts of organisms die before they can be eaten.
6. Grasses and herbs are the producer trophic level. Seed-eating birds, grasshoppers, and field mice are the primary consumer level. Spiders represent the secondary consumer level.
7. Energy trapped by grasses and herbs in photosynthesis is Net Primary Productivity + Respiration:
 $20.4 \times 10^6 + 36 \times 10^5 = 24 \times 10^6 \text{ kJ/m}^2/\text{a}$.
8. The photosynthetic rate of the grasses and herbs may be limited through much of the year by low temperatures and/or shortages of nutrient chemicals. Very little photosynthesis occurs in winter. This is normal.
9. The following are the net primary productions of each group:
- seed-eating birds: $60\,000 \text{ kJ/m}^2/\text{a} - 59\,200 \text{ kJ/m}^2/\text{a} = 800 \text{ kJ/m}^2/\text{a}$
 - grasshoppers: $444\,000 - 374\,300 = 69\,700 \text{ kJ/m}^2/\text{a}$
 - spiders: $700 - 500 = 200 \text{ kJ/m}^2/\text{a}$
10. Field mice lose the following amount of energy through respiration and feces (body waste, droppings):
 Energy Ingested – Net Primary Productivity: $116\,000 - 2\,000 = 114 \times 10^3 \text{ kJ/m}^2/\text{a}$

11.



12. The two problems involved in plotting the graph of energy flow are
 - The scale had to be adjusted from the producer level to the primary consumer (herbivore) level.
 - Seed-eating birds and field mice do not fit the energy flow in terms of a food chain (they also occupy the primary consumer level but obviously are not eaten by spiders) but could be added to the grasshoppers for an overall herbivore total. Decomposers are missing.
13. Since the producers are in an overabundance one might expect the numbers of herbivores to increase. With an increase in grasshoppers, spiders also would be expected to increase in numbers, biomass, and energy.

Section 2: Activity 2

1. Monoculture refers to the growth of one type of vegetation in a given area. It usually pertains to farms and the growth of cereal grains.
2. The biomass of producers is different in the spring, summer, fall, and winter. Winter has the lowest amount of energy available to sustain plants. With less biomass at the producer level, fewer consumers can be supported. Migrations of birds in preparation for this diminished energy and the hibernation of some mammals reduces the demand on producer energy.
3. The two major categories are
 - natural changes, e.g., retreating glaciers, floods, volcanic eruptions, earthquakes, fires
 - human-induced changes, e.g., land clearing, fires, strip mining, flooding due to dams, pollution
You could also include monocultures.
4. Fossil records indicate that biological diversity has increased over time. The number of species has gone from 150 different animal families about 500 million years ago to 6 to 15 million different species now living on the earth.
5. Biodiversity refers to an ecosystem in which a great number of different species form food webs and interact freely and dynamically.
6. Decreased biodiversity will limit the availability of different organisms within the trophic structure. Over time this will weaken the food web because a disease which affects one organism may eliminate it and seriously disrupt the energy flow within it. The more diverse a food web is, the more able it is to withstand stresses on it. Diversity creates stability. You can guess what a monoculture creates.
7. The elimination of wild species of plants removes the possibility that the plant species could be of benefit to humankind. This species could be lost forever at great cost.
8. The soil of the tropical rain forests requires the renewal of decomposed matter to maintain suitable amounts of nitrogen and phosphorus. Due to the removal of natural matter, the needed nutrients are no longer available and the soil will no longer support the growth of crops. Since the soils will not support the growth of the monocultures after a few years, this plan to remove the tropical rain forest and replace it with agrarian monocultures is not successful. It may eventually create a biological desert. The greatest biodiversity exists in tropical rain forests with many species that have not been classified.

Section 2: Activity 3

1. The following are five reasons given for the destruction of wetlands:
 - building of cities
 - building of highways
 - drainage of wetlands
 - ploughing of nesting sites
 - overgrazing by domestic cattle
2. The following are three management strategies:
 - Preserve: Maintain the wetland in its present state by protecting it from destructive intrusions.
 - Restore: Bring the wetland area back to its former condition.
 - Enhance: Add to an already existing site to improve wildlife production.
3. Nathan, from the Brooks area, researched Enhancement in Kitsum and Antelope Creek. He found that the river basins could be irrigated to improve wetland habitats. Also, overgrazing was a problem that could be overcome by limiting the range movements of cattle and allowing native grasses a chance to grow and provide adequate nesting sites for about 5 to 6 weeks in the spring. Afterwards the ranchers benefited with better grazing land and the waterfowl had achieved their nesting potential.

Katie, from the Edmonton area, researched an area of Preservation in the Buffalo Lake region. She found that nesting sites needed protection and preservation which was achieved by having farmers reduce their cultivation and leave a suitable area around pond margins for ducks to nest. She found that clover and hay provide good nesting sites. The land around the potholes was therefore managed more adequately.

Chris, from the Peace country, researched a Restoration Project near Kleskun Lake. He found that this area occupied about 7500 ha at the turn of the century and was an important staging and moulting area for waterfowl. Drainage had dried out parts of the lake and flooding has occurred in the past few years. The solution was to build a dike to store water in the spring and slowly release it to maintain the wetland habitat. This saved a valuable habitat and the birds are now back in significant numbers.

4. The concluding message is that humans can't stop building and caring for wetlands. Human intervention can destroy or restore ecosystems. Wetlands must be restored.
5. The degradation and loss of habitat, especially on the prairies, accounts for the decline of the duck population during this time. This habitat loss is associated with the following:
 - drainage of potholes and other wetlands has destroyed 40% of the original prairie wetland habitat
 - loss of native grasslands around the remaining wet areas (eliminating nesting sites)
 - expansion of farm operations
 - degradation of soil through erosion and salinization
6. The Waterfowl Management Plan provides incentives for farmers to manage their lands in a sustainable way, both for agriculture and waterfowl. Cash payments are given to farmers for seeding grasses on marginal lands or for fences to allow pasture rotation, thereby retaining nesting cover. Also, there is an improved payment plan for crop damage caused by waterfowl. All this is in place of the previous plans of buying large tracts of land.
7. The goal of the waterfowl managers is to restore the waterfowl populations to near the 1970s values and make the land less vulnerable to climatic change. This depends, in part, upon the success of global environmental issues, especially global warming, since the wetland habitats would be affected by increased moisture loss.

8. The following are reasons why cattails are important to nature's balance:

- They remove excess nitrogen and phosphorus that may enter the water from fertilizers, manure, eroding top soil, domestic sewage, or industrial discharge. Left unchecked, these nutrients can lead to algae blooms which choke waterways and lower oxygen concentration.
- They purify water by removing up to 90% of the nitrogen and phosphorus in raw sewage when the root system is mature and well established.
- In the fall, sugars and starch are stored in the root system and the stems and leaves wither and die. In a managed marsh, the dead material can be removed since it contains the absorbed excess nutrients.
- Cattails provide a food source for many animals including white-tailed deer, muskrat, beaver, and certain waterfowl.
- In the spring, the fruiting spikes can be roasted and eaten like corn and the roots can make flour with more protein than corn or rice.
- Cattails also produce a natural insecticide that will actually discourage the production of mosquitoes in a healthy wetland.

Section 2: Activity 4

1. Pros to the proposal of building a mill

- Larry Duniece, businessman and sport fisherman: If government standards are set and adhered to, the effluent will be safe and no one will get poisoned. If these standards are followed, the river will be clean from the icefields in Jasper National Park to Lake Athabasca. If the mill at Whitecourt followed suit to the one proposed here, I'd be quite happy.
- Rebecca Hutchinson, student, Edwin Parr High School, Athabasca: The proposed mill should be built because it will be a boost for the economy. A pollution-free mill isn't realistic and the company's assurances of safety are a sufficient guarantee. The community is aging because young people have to leave to find jobs. The mill will offer work and other spin-off jobs.
- Jeanette Plante, town councillor and businesswoman: The water quality hasn't deteriorated in over 40 years. Alberta Environment is monitoring the proposed mill very carefully. It is expected that water quality will improve because public awareness is so high.
- Laudy Lickacz, chemical engineer and technical superintendent of Weldwood Canada, Hinton: The building of additional mills on the Athabasca will diversify the economy. The expansion license demands more stringent BOD which the mills will meet. Dioxins in the effluent are in parts per trillion, not ppm, and are virtually undetectable. Industry and the public have the same objectives – a clean environment and a healthy economy.

Con to the question of building a mill

- Louis Schmidtroth, member of the Friends of the Athabasca: Economic concerns are put ahead of environmental ones. Environmental guidelines are not strong enough. Legal restraints should be more binding and enforceable. If this is not in place, the proposed mills would have less accountability.

Caution/Undecided to the question of building a mill

- Dr. Woodrow Morrison, social planner, Indian Association of Alberta: Money seems to be more important than human lives. Science thinks it knows a whole lot . . . breaking down knowledge into the smallest components, but so many mistakes have been made in the past.
- Sue Lysyk, editor of High School newspaper, student: If the mill gets built, it will mean jobs and a lot of money pouring into the town's economy. We really need that. On the other hand, the mill will also have an effect on the quality of water in our river. Will it be safe to drink? What will happen to the fish and animals that depend on the river?
- Leigh Noton, limnologist and project manager, Alberta Environment: Dioxins from the mill effluent were found. The winter water quality survey showed the following: levels of dissolved oxygen (DO) downstream of the mill effluent were low; provincial and federal limits of DO, phenolic compounds, colour, odour, and phosphorus were exceeded in the effluents; municipal sewage caused small to moderate increases in nitrogen, phosphorus, and bacteria.
- Judy McElligott, mother and homemaker: There is a conflict between economics and the environment. What is needed is comprehensive legislation, good monitoring, and the highest standards. With chemicals in the river, what are the future consequences for the following generations?
- Dr. Steve Hrudy, environmental engineer and professor of Environmental Health at the University of Alberta: DO is a high priority, as it is a fundamental parameter in assessing the impact of development. Replacing the oxygen rather than managing waste is treating the symptoms rather than the disease. The river must not be used as part of the treatment system.

Waste from the mills is higher than it should be. Dioxins and furans are a smaller concern when compared to the hundreds of chemicals whose names we can't pronounce and about which we know nothing.

- Niki Stady, student, Edwin Parr High School, Athabasca: There is concern for the economy and the environment. If there's going to be a mill, it should be the thermomechanical kind that doesn't use as many harmful chemicals in the process and is environmentally safer.

2. Five factors that affect water quality are

- | | | |
|----------------------|-----------------------|------------------|
| • dissolved oxygen | • dissolved nutrients | • microorganisms |
| • dissolved minerals | • suspended solids | |

The units used to express these factors are mg/L (milligrams per litre) or ppm (parts per million)

3. Of the natural components in river water, dissolved oxygen is the most vital: 6.5 ppm is the 1989 Federal guideline for all stages of aquatic life except the early stages (e.g. larval), for which the guideline is 9.5 ppm. The river adds oxygen in three ways – at the surface by contact with the atmosphere; through photosynthesis by aquatic plants; and in turbulence (e.g., waterfalls and rapids).
4. Winter water quality is important because much of the water is covered with ice so photosynthesis is at a minimum. Winter is also the time of lowest flow in the river, thus the same amount of effluent will be more concentrated.
5. BOD (Biochemical Oxygen Demand) represents the relationship between effluent and dissolved oxygen. It is the amount of oxygen used for oxidation by a unit volume of water at a given temperature in a given time. It is used as a measure of the degree of organic pollution of water. The more organic matter in the water, the more oxygen is used by microorganisms.

6. High BOD values indicate a high amount of organic material present in the water which will be acted upon by microorganisms which break it down. The higher the BOD, the greater the competition among aquatic life for the dissolved oxygen supply.
7. The three objectives of Alberta Environment are to assess the impact of existing effluent on water quality, to gather data for water quality protection planning, and to set a baseline for present winter-water quality conditions.
8. Dioxin and furan were missing from the list of toxic substances measured, but they were the subject of a preliminary survey in 1987. Dioxins were found to be present in the effluent and downstream from the mill. No dioxin appeared in samples of benthic invertebrates and sediments upstream from the mill. These substances spark such controversy because they are byproducts of the bleaching process in paper formation.
9. Effluent enters the Athabasca from the two existing pulp mills at Hinton and at Whitecourt, the Athabasca Tar Sands plants of Suncor and Syncrude, and several municipalities on the Athabasca River.
10. Personal points of view will be expressed based on viewing the video and from media exposure.

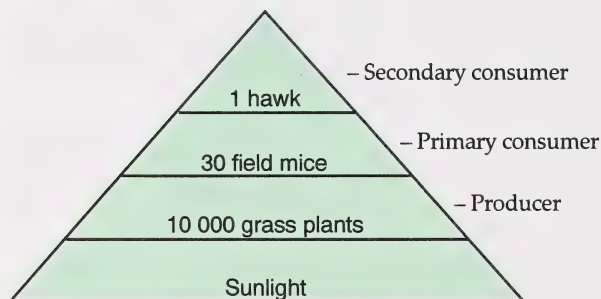
Section 2: Follow-up Activities

Extra Help

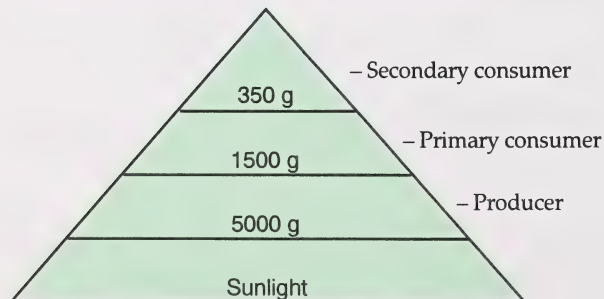
1. a. Matter flows from the air, soil, and water into the grasses; then to the mice; and finally to the hawk. Matter also flows from the grasses, mice, and hawk to decomposers which return the matter to the soil.

Energy flows from the sun into the grasses then to the mice and hawk. Energy also flows from the grasses, mice, and hawk to decomposers.

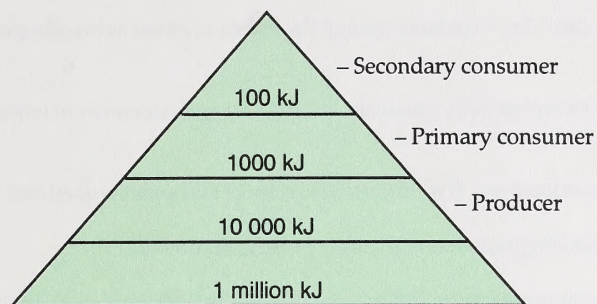
b.



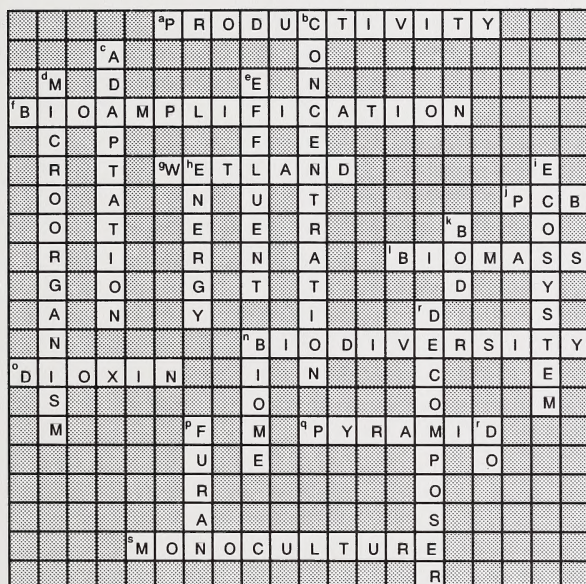
c.



d.



2.



Enrichment

1. a. Write to the following address:

Environment Council of Alberta
4th Floor, 9925-109 St.
Edmonton, Alberta
T5K 2J8

Be sure to explain why you want a copy of Canada's Green Plan and follow up with a thankyou letter.

- b. Some attempts by business and industry to protect Canada's environment include waste reduction, heat recovery, and recycling. Many large businesses and industries have people employed just to deal with environmental concerns.

- c. Can you add to the points and counterpoints? Try to balance each of the points to reflect as broad a point of view as possible.
2. In your letter requesting information, be sure to explain why you want information and remember to follow up any materials with a thank-you letter.
3. Many people may feel quite strongly about development. It is important to respect the opinions of others.
4. Ducks Unlimited Canada is a very approachable organization with many projects in Alberta.
5. Greenwing Programs are usually held in the summer months and may involve students from across Canada. Another group you might approach is the Alberta Forest Service. Ask about the Junior Forest Warden Program and Junior Forest Rangers.

N.L.C./B.N.C.



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